A LABORATORY STUDY OF HOUSEHOLD CHEMISTRY

JONES

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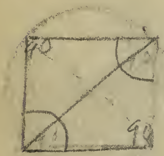

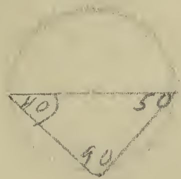

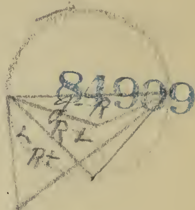

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A LABORATORY STUDY

OF

HOUSEHOLD CHEMISTRY

BY

MARY ETHEL JONES

FORMER TEACHER OF CHEMISTRY IN THE
LOS ANGELES HIGH SCHOOL

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PREFACE

These experiments in Household Chemistry are arranged to meet the demand for work in chemistry for girls. They form a practical course in the chemistry of the household and of common things, and are helpful both to pupils who do not go to college and to those who do.

Above all, the course is practical. While the fundamental principles of chemistry are as thoroughly emphasized in the first half year of this course as they are in any course in general chemistry, the experiments that illustrate them are made as practical as possible.

The last half of the course is largely organic chemistry made as *simple as possible* and used so far as possible in the study of fuels and illuminants, food principles, food substitutes, textiles, soaps, laundering, bleaching, blueing, dyeing, and leavening agents.

All of the experiments and the wording of the directions have been tried for five years by different teachers with classes of girls. Additions and changes have been made each term until the manual satisfies all the requirements of the course.

Many teachers have assisted in the preparation of this work. The author wishes particularly to express her indebtedness to Miss J. Maud Blanchard, her first teacher in chemistry, to Miss May Kimble and Mr. J. H. Hanna, both of the Los Angeles High School, and to Mr. C. W. Sandifur, of the Hollywood High School.

Mary Ethel Jones

Los Angeles, California
April, 1921

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Part I. First Term's Work

Part II. Second Term's Work

SUGGESTIONS TO TEACHERS

As has been noted in the preface, this manual was not written to fit any particular textbook, but simply to outline a course in chemistry for girls. It has been found that any good up-to-date book in elementary chemistry can be used throughout the year's work. On the second term's work, however, it is well to give some reference work from the books mentioned.

Most of the experiments can be performed in the double laboratory period of 90 minutes. Some of the experiments are short enough so that two experiments can be performed in one day. A few experiments require more than one double period.

It has been our experience that a student will work to far better advantage in the laboratory if the instructor will spend five, or even ten, minutes at the beginning of the laboratory period discussing the experiment, emphasizing in particular the purpose of the experiment and the precautions to be observed. With a beginning class of girls, until they know something of laboratory technique, it is well to show just how the apparatus in the experiment is set up.

The method of presenting the principles and just where and when to introduce the theories of chemistry to a beginning class of girls, varies with different teachers. There is an outline on food chemistry in the appendix that may be helpful to the students.

IMPORTANT SUGGESTIONS TO STUDENTS

1. Pay your laboratory fee. No student may be assigned a desk in a chemical laboratory until this fee is paid. Your instructor will keep your receipt on file until you need it to present for refund.

2. Provide yourself with the following: a rubber or oilcloth apron, the standard laboratory notebook, some mop cloths, a cake of soap, one fourth of a cake of sapolio, and a sponge.

3. If you break a piece of apparatus, make out a requisition slip for a new piece and replace it.

4. Always keep your apparatus clean and your desk neat. Good chemists are never slovenly.

5. Keep the sink in front of your desk clean. — Do not put acids or strong bases in it without flushing it well. Do not put matches, fats, oils, paper, pieces of sodium or potassium into the sink, but use the waste jars provided.

6. Do not use more material than the amount specified. If too much is taken of either a solid or liquid, throw the excess into the waste jars; never pour it back into the bottle.

7. Never lay the stopper of a reagent bottle down on the shelf; keep it in your hand and replace it when you are through.

8. Never taste reagents unless told to do so.

9. In case of accident see instructions on page xv; if serious, report to instructor.

10. Your notebook should be an honest record of your own observations and conclusions.

SAFETY RULES

1. Before a new experiment is begun at least ten minutes should be spent in the lecture room:
   a. To emphasize precautions to be observed in order that the experiment may be *absolutely safe.*
   b. To make clear the *purpose* of the experiment.
   c. To make the *method* clear.
2. Experiments missed by a student are *not* to be made up in the laboratory unless carefully supervised by the instructor.
3. Have no materials on the distributing shelves *except* the materials for the experiment of the day.
4. All other supplies should be kept in the storeroom and the storeroom kept locked.
5. Poisons and materials not safe in the hands of students such as potassium cyanide, phosphorus (yellow), sodium, potassium, carbolic acid, and mercury salts, should be locked in a special cupboard.
6. In the preparation of oxygen be sure that the manganese dioxide is free from carbon before it is mixed with the potassium chlorate. The teacher should perform the experiment in front of the class before allowing them to do it.
7. Such substances as potassium chlorate, phosphorus, sodium, potassium ammonium nitrite, concentrated sulfuric acid, and concentrated nitric acids are not safe in the hands of the students in the crowded classes of the High School. Experiments involving the use of these substances should be performed by the instructor.

8. Other experiments in which poisonous gases are prepared, such as chlorine, bromine, or phosphine, should be performed by the teacher.
9. Unless the class is so small that the teacher can personally direct each student, the experiment on the preparation of hydrogen by *any* method should be performed by the teacher.
10. All experiments involving reductions by means of hydrogen or the burning of hydrogen should be performed by the teacher.
11. Keep your first-aid closet well stocked.
12. Carry all acid bottles with both hands, one on the bottom, one holding the neck. Carry one bottle at a time.

LABORATORY FIRST AID

1. **Accidents,** if serious, should be reported to the instructor.
2. **Cuts.** Wash in running water, then with a piece of absorbent cotton saturated with iodine solution. Bandage to prevent contamination.
3. **Burns** caused by *hot objects.* Cover with a paste made by mixing sodium bicarbonate and carron oil (equal parts of olive oil and lime-water). Then cover with cotton and bandage.
4. **Burns** caused by *acids.* Wash with water, apply a solution of sodium bicarbonate, then treat as in 2.
5. **Burns** caused by *alkalies.* Wash with boric acid, then treat as in 2.
6. **Acids in eyes.** Wash with water, then dilute solution of sodium bicarbonate, then olive oil. *Do not rub.*
7. **Bases in eyes.** Wash with water, then boric acid solution, then oil. *Do not rub.*
8. **Other substances in eyes.** Use water, boric acid, then oil. *Do not rub.*
9. **If a chemical is swallowed** call a physician. Meanwhile, give emetic of mustard and warm water. Consult " First Aid " for antidote.
10. **If irritating gases are inhaled** — breathe fresh air. In case of *hydrogen chloride, sulphur dioxide, chlorine, or bromine,* a very dilute solution of ammonium hydroxide sniffed into the nose often brings relief. If the gases are in the eyes, bathe with water and boric acid. If overcome by *hydrogen sulfide,* inhale chlorine gas (prepared quickly by treating powdered potassium chlorate in a beaker with a few drops of hydrochloric acid at a time).

HOUSEHOLD CHEMISTRY

PART I

FIRST TERM'S WORK

I. PRELIMINARY EXPERIMENTS

UPON entering the laboratory, hang your coat upon the hooks provided, roll back your sleeves, put on your apron, and check your apparatus with the following list. If anything is missing or not in good condition, report to the instructor. After the first day, broken or lost apparatus will be charged to your account.

APPARATUS LIST

1	Asbestos mat	$0.10
1	Beaker, 150 cc.	.35
1	Beaker, 250 cc.	.40
1	Crucible, porcelain, #0	.35
1	Clay triangle	.05
1	Cover for crucible, #0	.15
1	Delivery tube, rubber, 18″	.25
1	Elbow glass, 3″×6″	.05
1	Elbow glass, 3″×3″	.05
1	Evaporating dish, porcelain, 50 cc.	.30
1	Forceps, steel, 5″	.15
1	Flask, Florence, 250 cc.	.25
1	Funnel, short stem, 3″ diameter	.30
4	Gas bottles, wide mouthed, each	.15
4	Glass plates (cover glasses), each	.10

1	Graduate (measuring cylinder), 50 cc.	.75
12	Gas testers, wooden splints	.05
1	Box matches, safety	
3	Rubber connectors (3″ rubber tubing)	.10
1	Stirring rod	.05
1	Stopper, 1-hole, pure gum	.10
1	Stopper, 2-hole, pure gum	.10
1	Test tube, side neck, 8″×1″	.20
12	Test tubes, 6″×$\frac{3}{4}$″ each	.05
1	Test tube, 8″×1″	.10
1	Test tube brush	.15
1	Test tube holder (bent wire)	.15
1	Thistle tube, straight stem (safety)	.60
2	Watch glasses, 2″	.05
1	Wire screen, 4″×4″	.10

PERSONAL LIST

Apron, cloths, sponge, soap, sapolio, paper.

After checking your apparatus, fold and put away your apron and lock the drawer and locker. Keep your key.

EXPERIMENT 1

The Bunsen Burner

Apparatus. Bunsen burner, matches, beaker, test tube, test tube holder, wire screen.

Note to student: When you enter the laboratory, put on your apron and begin the experiment at once. Work independently unless otherwise instructed. Do not waste time. Unfinished experiments will have to be finished after school. Put your name, the date, the number of the experiment at the top of a page in your notebook and record carefully each observation as you work. Be sure to have the instructor sign your notes before you leave the laboratory. Always bring your laboratory notebook with you on recitation days in order that the experiment just performed may be discussed.

Note to teacher: Much time will be saved if the parts of the Bunsen burner are briefly explained before the students enter the laboratory. Also show how to heat a liquid in a test tube and how to use a ring stand.

A. The Parts of the Burner.

The Bunsen burner is a form of apparatus used for the burning of gas. It is the usual source of heat in the laboratory. The name "Bunsen" has been given to the burner because it was first made by the German scientist Bunsen. It consists of a base and a tube which has two round openings in its lower part, through which air enters. A small band, with corresponding openings, fits the lower part of the tube, and by turning this the holes in the tube may be kept open or closed. The gas enters by means of a rubber tubing through the base. It mixes with the air that enters the openings in the tube and is burned at the top of the tube.

1. Unscrew the tube of the burner and examine the parts. Draw each part and label it. Put it together again and light the gas. To do this light a match and hold it about two inches above the end of the tube, then turn on the gas. If a burner "strikes back" and burns at the base, shut off the gas and light again. The flame should not be more than four inches high at any time.

2. Shut off the air by closing the holes at the base. What happens to the flame? Open the holes again and admit air. Which flame is best for laboratory work? Why? Put one of your splints into the base of the blue flame and gradually raise it. What part of this flame is the hottest? Upper Part

B. How to Heat Glass Apparatus in the Bunsen Flame.

1. *To heat water in a test tube.* Half fill a test tube with water, wipe the surface dry. Place the test tube clamp about the top of the test tube, as directed by the instructor. Incline the tube away from your face, but not toward your

neighbor. Apply the heat near the top of the liquid. Move the tube about in the hottest part of the flame, so that it may be uniformly heated. When the water boils, pour it into the sink and put the tube away.

2. *To boil a beaker of water.* Place a wire screen on the ring of your ring stand. Place the burner under the screen and adjust the ring so that the screen presses down about one inch of the flame. (Note the instructor's model.) Half fill the beaker with water, wipe the surface dry, and place it on the screen. If the beaker were heated without the screen, it would probably break. How does the screen prevent this?

C. Before Leaving the Laboratory.

Wash your apparatus and put it away. Be sure to put away your screen. Put the burnt matches and other scraps into the jars. Wipe the desk top with a cloth. Clean up in this way after every experiment hereafter. *Be sure to lock your drawer and locker.* The instructor must sign your notes before you leave the laboratory. Bring these with you at the next recitation.

EXPERIMENT 2

The Units of Length, Volume, and Weight Used in Chemistry

REFERENCE. Appendix in this manual.

APPARATUS. A meter stick, a short metric ruler, flasks representing 1 l., 500 cc., 250 cc., 100 cc., balance.

Note to student: Take careful notes. Number and letter the paragraphs in your notes to correspond to the paragraphs in the manual. If you do not understand the directions, ask the instructor for help. Have your notes signed before leaving the laboratory. Bring the notes for discussion at the next recitation.

A. Unit of Length.

The unit of length most often used in chemistry is the centimeter. Examine a meter stick and notice that a meter is more than a yard long. How many inches are there in the meter stick? How many centimeters in the meter? Draw a line one centimeter long and write the abbreviation 1 cm. over it. How many millimeters in a centimeter? 10 Divide the line you have just drawn into millimeters. What is the abbreviation for a millimeter? mm Using the small ruler measure the length of your Bunsen burner tube in centimeters; 10 the diameter of the tube. Measure the length and diameter of a test tube and your beaker. 15 cm 6.9 cm

1.7 cm 5.2 cm

B. Unit of Volume.

The cubic centimeter is the unit most often used. Its abbreviation is cc. Draw a cube with each edge one centimeter long. This represents a volume of one cubic centimeter. There are one thousand cubic centimeters in a liter. Examine flasks with capacities of 1 l., 500 cc., 250 cc., and 100 cc., respectively. From the size of your flask, as compared with these, what do you think is its volume? Measure 1 cc. of water in your graduated cylinder; measure 50 cc. (Read the lower part of the curved surface always.) Now, using the graduate, fill the flask and measure its volume. In like manner measure the volume of your beaker and test tube.

C. Unit of Weight.

The gram is the common unit of weight. Its abbreviation is g. Imagine the cube you have drawn in **B** to represent one cubic centimeter filled with water. The weight of this water would be about one gram. There are one thousand grams in a kilogram. If one cubic centimeter of water

weighs one gram, how many grams of water will your flask hold? your beaker? your test tube? Learn how to use the balance, then weigh your beaker.

Note: Return the meter sticks and rulers to the distributing table. Put away your apparatus. Clean and lock your desk as usual.

D. Problems.

1. A tank is 500 cm. long, 200 cm. wide, and 90 cm. deep. How many cubic centimeters of water will it hold?

2. If one cubic centimeter of water weighs one gram, how many grams of water will the tank in problem 1 hold?

3. A potato weighs 9 ounces. How many grams does it weigh?

4. What is your own weight in kilograms?

EXPERIMENT 3

How to Make Simple Apparatus from Glass Tubing

MATERIALS. Soft glass tubing, external diameter 5 mm. or 6 mm. (about $\frac{1}{4}$ of an inch).

APPARATUS. Triangular file, fish-tail attachment for the Bunsen burner, meter stick or ruler, a Bunsen burner.

Note to student: The laboratory notes will be mere statements of what you did.

Note to teacher: Before entering the laboratory, show the students how to cut, bend, round sharp edges, and seal glass tubes.

A. To Make a Glass Elbow or Delivery Tube.

Glass elbows or delivery tubes are simple pieces of apparatus used to conduct gases from one vessel to another. To make a short one: (1) Cut off a piece of glass tubing 15

cm. long (about 6 inches). (2) Bend at right angles in the middle and (3) smooth each end. Follow the instructor's directions as closely as possible.

1. To cut a glass tube, place it on the table, measure off the required length, and at this point make a scratch with the triangular file. Pick up the tube with both hands. Place thumbs on both sides of the scratch and opposite it. Press up with the thumbs and down with the hands. The break should be even.

2. To bend a glass tube, hold it lengthwise in the flat flame produced by the fish-tail attachment. Rotate it constantly until it is soft, then take it from the flame and bend it at right angles. Hold it so until it hardens. The bend should be smooth. Show it to the instructor for approval or advice before making a new one.

3. The elbow cannot be used as it is because the sharp ends would cut the rubber stopper. Make each end smooth by heating it in the ordinary Bunsen burner flame till the glass begins to melt slightly.

4. Make a long, glass elbow in the same way, using about 30 cm. of tubing, making the bend about 8 cm. from one end. This also should be approved before it is put away.

B. To Make a Stirring Rod.

Cut off a piece of glass rod about 25 cm. in length. Heat the ends in a Bunsen flame till they are soft and round. Place it on the iron base of your ring stand to cool. Never put any hot glass or hot apparatus on the top of the table. After your rod has been approved put it away. Have your notes signed.

EXPERIMENT 4

Physical and Chemical Changes

MATERIALS. Granulated cane sugar.

APPARATUS. Beaker, test tube, mortar and pestle, Bunsen burner, ring stand, wire screen, test tube holder.

Note to teacher: It is convenient to measure out the proper amount of material on squares of paper on the distributing table ready for the students. This saves a great deal of time and material.

A. How Sugar May Be Changed.

1. Take a clean dry test tube and obtain about 10 grams of sugar from the distributing table. (NOTE: Be careful not to spill material on the distributing table — if you do, clean it up. Hold the stopper of the bottle in your hand and replace it when you are through.) Carefully note the properties of the sugar, its crystalline form, its hardness, color, and taste. How could you distinguish it from table salt? What then is its most *characteristic* property?

2. Put about half of your sugar in a clean mortar and grind it till it is a powder. Taste it. Is it still sugar? yes Has its characteristic property been changed by grinding? a little This is a physical change, because the composition of the substance is unchanged, as is shown by the fact that no change in the characteristic properties has occurred.

3. Fill your beaker one fourth full of water and add the powdered sugar from the mortar. Stir with your stirring rod until the sugar is dissolved. Taste the solution. Has the sugar been destroyed? What has happened to it? This is a physical change.

4. Heat the remainder of the sugar in a dry test tube until it stops smoking. Note every change carefully. When

no further change takes place, cool the tube, break it, and examine the substance remaining in the tube. What is its form, its hardness, color, and taste? Will it dissolve in water? Try it. Has the substance any properties of sugar? This is a chemical change, because the composition is changed and a new substance is formed, having new properties.

B. How Other Substances May Be Changed.

Tear a piece of paper into bits. Is the change physical or chemical? Why? Burn a piece of paper. Describe the change. Is it a physical or a chemical change?

C. Some Changes We See Every Day.

Are the following changes physical, or chemical, or both? Give a reason for your answer in each case. 1. The souring of milk. 2. Making a batter from flour, milk, and eggs. 3. Baking bread. 4. Making candy. 5. Beating an egg. 6. Boiling an egg. 7. Freezing cream in making ice cream. 8. Tarnishing of copper.

Note: Have your notes signed.

EXPERIMENT 5

Elements, Compounds, Mixtures

MATERIALS. Sulfur, about 5-gram portions, magnesium ribbon, 3 cm. strips, mixture of equal parts powdered sugar and sulfur, 10-gram portions, Shaker Salt 10-gram portions.

APPARATUS. Evaporating dish, forceps, Bunsen burner, filter paper, funnel, stirring rod, two beakers.

Note to teacher: Before entering the laboratory, show how to fold a filter and the correct method of filtering.

Note to student: Take careful notes and have them signed before leaving laboratory.

A. **Elements.**

1. Obtain 5 grams of sulfur in a test tube. Examine it carefully. What are its chief *physical properties, i.e.* color, odor, taste. Try to dissolve a little in a test tube half full of water. Is it soluble in water? Is sulfur a metallic or a non-metallic element? Can you find in the Appendix the names of three common non-metallic elements?

2. Obtain a piece of magnesium ribbon about 3 cm. long. Notice its color and weight, its luster, and its flexibility. Is it a metallic or a non-metallic element? Give the names of three common metals and give a use for each.

3. Repeat 2, using aluminum instead of magnesium.

4. Now tell in your own words what an element is.

B. **Compounds.**

1. Place a little sulfur about the size of a pea in your evaporating dish. Heat the sulfur by means of the burner flame till it burns. Very carefully note the odor. Is this a physical or chemical change? We have noted the *physical properties* of sulfur in **A**, 1. We have now observed one *chemical property* of sulfur. What is it? The gas that is formed when sulfur is burned is sulfur dioxide. It is a compound.

2. By means of the iron forceps hold the piece of magnesium ribbon in the flame. Result? What is formed? Has the new compound any of the properties of the metal magnesium or the gas oxygen from which it was formed? In general, what is formed when an element burns in the air? Give a chemical property of magnesium.

3. Repeat 2, using aluminum instead of magnesium. What is formed? Give a chemical property of aluminum.

4. Is sugar an element or a compound? How did you prove this in the preceding experiment? What is one element in it? Consult the textbook and find out the other elements in sugar. What are the elements in table salt (sodium chloride)? in water?

5. What is a compound?

C. Mixtures.

1. A well-known remedy for sore throat consists of a mixture of equal parts of sulfur and powdered sugar. Obtain from the instructor about ten grams of this remedy in your beaker. Fill the beaker half full of water and boil for about one minute, stirring occasionally. Which constituent of the remedy will dissolve? Which one will not? Remove the beaker from the ring stand and filter. The solid will remain on the paper and the liquid will pass through it.

To prepare a filter paper fold it once and then again at right angles to the straight edge. Open the paper as a cone, with a triple layer of paper on one side and a single layer on the other. Place it in the funnel and moisten it well with water. The paper should not come to the top of the funnel. Place the funnel in the ring of the ring stand. Place the other beaker under the funnel. Adjust the ring so that the stem of the funnel extends into the beaker about one inch. To pour the liquid from the beaker into the funnel without spilling it hold the glass rod lightly against the rim of the beaker. The liquid will flow down the rod. The liquid that goes through the filter paper is called the *filtrate*.

Taste the filtrate. Where is the sugar? Where is the sulfur? If a mixture consists of two substances, one soluble

on filter paper

in water and one insoluble, what is the general method of separating them?

2. "Shaker Salt" is pure sodium chloride (table salt) to which has been added a little starch to keep it dry. Starch is not soluble in water. Obtain ten grams of "Shaker Salt." Stir it into half a beaker of cold water. Is starch present?

3. Now define a mixture clearly.

II. OXYGEN AND HYDROGEN

EXPERIMENT 6

Ways of Freeing and Collecting Oxygen

MATERIALS. Powdered potassium chlorate 8-gram portions, splints (about the size of a match and 7 inches long), powdered manganese dioxide 2-gram portions.

APPARATUS. Bunsen burner, test tubes, gas bottles, pneumatic trough, glass plates.

A. How to Obtain Oxygen.

1. Oxygen is the gas in the air which makes a fire burn. The air would be an excellent source of oxygen if it did not have so much nitrogen mixed with it. It is difficult to remove the nitrogen and leave the oxygen.

2. The compound potassium chlorate, $KClO_3$, is the most convenient source of oxygen. Obtain 8 grams of powdered potassium chlorate and 2 grams of manganese dioxide. Divide the potassium chlorate into two equal parts. Put one part (4 grams) in a clean, dry test tube. Mix the other part (4 grams) on a piece of paper with 2 grams of manganese dioxide (half as much), using the stirring rod. Then put it into a clean, dry test tube of the same size as the first.

3. Heat the first tube gently and with a glowing splint test for oxygen. If oxygen is present, the glowing splint will burst into flame. Now heat the tube intensely and test for oxygen. What effect has increased heat? When oxygen is no longer given off, a new compound, potassium chloride, remains in the tube.

4. Now heat the second tube containing the mixture of potassium chlorate and manganese dioxide.

Important: If this mixture sparks (gives flashes of light), call the instructor to look at it. It means that the manganese dioxide contains carbon and is not safe to use in the next experiment. Small sparks are due to dust.

Test with the glowing splint as before. The manganese dioxide undergoes no change. It causes the potassium chlorate to give up its oxygen at a lower temperature. It increases the speed of the reaction. What is such a substance called? (Consult your textbook.) When oxygen is given off no longer, what is left in the test tube?

Note: To clean the test tubes in 3 and 4 fill them with water and let them stand overnight.

B. How to Collect Oxygen and Other Gases.

1. The most convenient method to collect a gas is by displacing water. Obtain a pneumatic trough and half fill it with water. Fill one of your gas bottles with water and slip a glass plate over the mouth, being careful to exclude all air bubbles. Hold the plate in place, invert the bottle in the water, and remove the plate. Raise the bottle a little; never lift the mouth of the bottle out of water. Why does the water stay in the bottle? Hold the bottle in this position and fill it with air from the lungs by inserting one end of a rubber delivery tube in the mouth of the bottle and carefully blowing through the other end.

When the bottle is full of gas, cover its mouth with a glass

plate (still under water), remove from the water, and place it on the desk. A bottle of gas so covered is placed right side up if the gas is heavier than air, or upside down if the gas is lighter than air.

2. A liter of air weighs 1.29 grams. A liter of oxygen weighs 1.43 grams. (See Appendix.) How then should a bottle of oxygen be placed?

3. A liter of hydrogen weighs .09 gram. Would you place the bottle upside down or right side up in this case in order to keep the hydrogen in the bottle the longest possible time?

4. The gas carbon dioxide is soluble in water. It is heavier than air. How would you collect it? How place the bottle?

5. The gas ammonia is also very soluble in water. It is lighter than air. How would you collect it? How place the bottle?

EXPERIMENT 7

Preparation and Properties of Oxygen

Note to teacher: Each student understands that work in the laboratory must be done alone unless otherwise directed by you. Unless the laboratory periods are very long it has been found more satisfactory to allow two students to work together on this experiment. Discuss the experiment briefly and show how the apparatus is set up before students enter the laboratory. Place the " set up " in the laboratory so that they may use it as a model.

MATERIALS. 20 grams powdered potassium chlorate and 2 grams of manganese dioxide mixed, pine splints, sulfur 1-gram portions, iron picture wire 15 cm. long.

APPARATUS. Pneumatic trough, four gas bottles (about 250 cc. each), four cover glasses, rubber delivery tube, short glass elbow, rubber stopper to fit large, hard-glass test tube, Bunsen burner, ring stand, test tube clamp, combustion cup.

A. Preparation of Oxygen — Laboratory Method.

1. Fill the pneumatic trough about half full of water. Fill four gas bottles with water, cover them, and invert in the trough as directed in Experiment 6, **B**. If a bottle has an air bubble, fill it again and invert.

2. Attach the rubber delivery tube to the short glass elbow, put the elbow into the one-hole stopper, and fit the stopper into the large, hard-glass test tube. If it does not fit well, exchange it for one that does. All joints must be tight or the oxygen will escape into the air. Attach the test tube clamp to the ring stand and support the test tube in a slanting position. Do not pinch the tube tightly or it will break when you heat it.

3. Obtain a mixture of 20 grams of potassium chlorate and 2 grams of manganese dioxide. Put into the hard-glass test tube, replace the stopper, and heat the mixture gently, at first holding the burner in the hand and moving the flame up and down on the tube. Put the end of the delivery tube in the water. The first bubbles are small and irregular bubbles of air. Soon large bubbles of oxygen should be evolved. Heat more gently if the gas comes too rapidly. Collect four bottles of gas.

Caution: Remove the delivery tube before you stop heating or the water will be drawn back into the hot test tube and break it. Why will the water be drawn back in this way?

4. What substance produced the oxygen? Why was the manganese dioxide used? Write in words the *equation* for the *reaction* that took place thus:

Potassium Chlorate + heat ⟶ Potassium Chloride + Oxygen

$$KClO_3 + \text{heat} \longrightarrow KCl + 3\,O$$

Since the manganese dioxide was not changed in any way, it would not appear in the equation.

B. Physical Properties of Oxygen.

The physical properties of a gas are its color, odor, taste, its solubility in water, and its weight as compared with air.

1. Uncover a bottle of oxygen, smell it, and inhale some of it through the mouth. Has it any odor or taste? Has it any color? Is it soluble in water? Is it heavier or lighter than air? Recall Experiment 6, **B**, 2.

2. Summarize the physical properties of oxygen.

C. Chemical Properties of Oxygen.

Chemical properties are those that are shown where a substance undergoes a chemical change.

1. Thrust a glowing splint into a bottle of oxygen. Remove it, blow out the flame, and thrust it in again. Do this as many times as you can. After a while the stick will not burst into flame. Why? Does oxygen burn? Does it *support combustion* (make other things burn)? What gas is now in the bottle? Was this a physical or chemical change? Write in words the equation for the reaction.

2. Obtain 1 gram of sulfur in your evaporating dish. Place half of this in your combustion cup. Hold it over the flame until it starts to burn. Notice the color and size of the flame. What is the gas formed when sulfur burns in air or in oxygen? Thrust it quickly into a bottle of oxygen. Notice the change in the flame. What is the gas formed? Write the equation in words to show what took place. Was this a physical or chemical change?

3. Fray one end of a piece of iron picture wire. Heat the frayed end and then dip it into the sulfur in your evaporating

dish. The wire is frayed and dipped in sulfur in order that it may start to burn more readily. Hold the wire in the flame till the sulfur burns, then thrust it into a bottle of oxygen. Result? Will iron burn in the air? no What new substance was formed in the bottle? What kind of change took place? Write in words the equation for the reaction that took place. When a substance burns in oxygen, what is always formed?

4. From these tests what is the chief chemical property of oxygen?

Note: Empty the pneumatic troughs and return them. Burn the sulfur out of the combustion cup before returning it.

Leave out

EXPERIMENT 8

What Takes Place When a Substance Burns

Note: This should be a class experiment if hoods are not available or if the class is large. It is a dangerous experiment.

MATERIALS. Yellow phosphorus, red phosphorus, sulfur (small amounts about the size of a pea), sulfur matches, parlor matches, safety matches.

APPARATUS. Bunsen burner, asbestos mat, forceps.

A. Slow Oxidation.

1. Half fill your evaporating dish with water and take it to the instructor for a piece of yellow phosphorus the size of a pea. Lift it out of the dish with the forceps and place it upon your asbestos mat. TAKE CARE! DO NOT TOUCH IT WITH THE FINGERS. What are its physical properties? As soon as the phosphorus becomes dry, do heavy white fumes arise? What are these fumes? Do you notice any light or heat? What is taking place?

2. When iron rusts, what is formed? Is there any noticeable light or heat? What is this process called?

B. Rapid Oxidation or Burning (Hood).

1. Carefully place a small amount (about the size of a pea) of sulfur one inch from the phosphorus. About the same distance away place a small amount of red phosphorus. The same distance away place a piece of pine splint. Raise the temperature of all by slowly heating with the burner turned low. Stand back and observe the order in which the substances take fire and burn.

2. Explain what takes place when a substance burns in the air.

3. What is meant by the kindling temperature of a substance?

4. Why is phosphorus kept under water?

5. Why was the untwisted picture wire tipped in sulfur before putting it in oxygen to burn?

6. Why are paper and kindling wood used to build a coal or wood fire?

7. Lacking kindling wood, kerosene is sometimes poured upon the coal or wood. Is this safe? Why?

C. The Study of Matches.

1. Examine the head of a sulfur match. The color, usually red, is merely a dye. Rub the head upon your moist hands in the dark. What causes the glowing streak? Smell the match head after rubbing it on your hand. What is in the tip of the match? Remembering the color of sulfur, see if you can observe sulfur on the wood next to the match head. Rub a match on a rough surface. What takes fire first? What produces the heat to raise it to its kindling tempera-

ture? What burns last? What produces the heat to make it catch fire? Name in order the substances in a sulfur match that burn, beginning with the one that has the lowest kindling temperature.

2. Examine a parlor match in like manner. What is used in place of the sulfur in this match? Name in order the substances in a parlor match that burn, beginning with the one that has the lowest kindling temperature.

3. What is a safety match? Why is it safe? Where must it be scratched?

Caution: Be sure that all of the phosphorus is burned from your mat before you put it away. See that no phosphorus clings to the forceps. If you have any unused sulfur matches or parlor matches, return them; it is not safe to put them away in the drawer or locker.

EXPERIMENT 9

Preparation and Properties of Hydrogen

Note to teacher: Before the students enter the laboratory discuss the experiment briefly and show how the apparatus is set up. Leave your " set up" before them as a model. Supervise closely, to avoid explosions.

MATERIALS. Granulated zinc 10-gram portions, splint, dilute sulfuric acid.

APPARATUS. A 250-cc. Florence flask, two-holed stopper, short elbow, delivery tube, pneumatic trough, four gas bottles, beaker, two test tubes, and a safety tube.

A. The Usual Method of Preparing Hydrogen by Action of a Metal on an Acid.

1. Carefully slip 10 grams of zinc into your flask; insert the stopper containing the safety tube and delivery tube. Keep the flask in an upright position by clamping it to the ring stand. Half fill the pneumatic trough with water and invert in it four gas bottles filled with water, as in the case of

oxygen. Have the four cover glasses near the trough ready for use when the bottles are full. Also fill two test tubes with water and invert them in the trough. (They may lie in the water on the bottom of the trough till you are ready for them.) Remove the stopper from a bottle of sulfuric acid by grasping it between the first two fingers of the right hand, palm up. Pick up the bottle with the same hand and pour acid into the thistle tube. Just touch the mouth of the bottle to the lip of the tube. Pour in acid till the zinc is covered. Then replace the bottle and the stopper. Always follow these directions when pouring a liquid from a bottle. Never put the stopper on the table or shelf, and if too much liquid is taken, never return any to the bottle. Keep it in a labeled test tube for future use or throw it into the sink.

If hydrogen comes from the acid very slowly, add through the thistle tube 5 or 10 cc. of copper sulfate solution. Why does this increase the action? Be sure that the apparatus is air tight.

2. Light the Bunsen burner. Caution! Keep it some distance from the apparatus, because at first the hydrogen is mixed with air and the mixture is explosive.

3. Allow the gas to escape into the air for about one minute, then collect a test tube of it. Put the thumb over the mouth of it and bring the tube, mouth downward, to the flame. If it explodes, the hydrogen is still mixed with air. Collect another test tube and try again. When the gas burns with a little puff at first, it is ready to be collected in the gas bottles. Collect four bottles of hydrogen; cover them and invert them on the desk. If the action stops before the bottles are filled, add a little more acid. Why remove the delivery tube from the water?

4. Where does the hydrogen come from? What was the use of the zinc? Could any other metal have been used?

B. Physical Properties of Hydrogen.

1. Examine a bottle of hydrogen; note its color, taste, and odor. (There may be a slight odor due to an impurity.)
2. Is it soluble in water? How do you know?
3. Uncover a bottle of hydrogen; hold it mouth upward while you count thirty, then test for hydrogen. Explain the results. Is the gas heavier or lighter than air?

C. Chemical Properties.

Hold a bottle of hydrogen mouth downward and quickly thrust a blazing splint into the bottle. Withdraw the splint and insert it again. Does the hydrogen burn? If so, where? Does the splint burn when in the bottle? when out of the bottle? Does hydrogen support combustion? Feel the neck of the bottle. Describe and explain. What properties of hydrogen are shown by this experiment?

D. What Remains in the Flask.

1. Pour the liquid from the flask into a beaker. Return the pieces of zinc to the instructor. Put the beaker in the locker until the next laboratory period. Then examine the contents of the beaker. What are the crystals? Did a physical or chemical change take place?
2. The equation for the reaction is as follows:

$$\text{Sulfuric Acid} + \text{Zinc} \longrightarrow \text{Zinc Sulfate} + \text{Hydrogen}$$
$$H_2SO_4 + Zn \longrightarrow ZnSO_4 + 2\,H$$

Hereafter, all equations will be written in this manner — first in words, then using *formulas* for the compounds and *symbols* for the elements. What are the compounds in the

reaction? Name each, and give the formulas for each. What is the metallic element? Give its symbol. What is the non-metallic element? Give its symbol.

EXPERIMENT 10

(Class Experiment)

Two Other Methods of Preparing Hydrogen

Note: In A 4 be sure that the tin foil is wrapped so tightly about the sodium that no air is included or an explosion may result.

MATERIALS. Sodium, potassium, sulfuric acid, distilled water.

APPARATUS. Pneumatic trough, knife, tin foil, iron or copper wire, 250 cc. gas bottle, glass plate, Hoffman apparatus, storage battery.

A. By the Action of Metals on Water.

1. Note the physical properties of sodium and potassium.

2. Cut off a piece of sodium the size of a pea and throw it upon the water in the pneumatic trough. What is the result? Explain.

3. Repeat, using potassium instead of sodium. Note the results. Explain.

4. With the sharp end of a file punch small holes in a piece of tin foil and wrap it firmly around a piece of sodium about the size of a large bean. Fill a 250 cc. gas bottle with water and invert it in the trough. Raise the bottle slightly and by means of a wire quickly thrust the sodium under the mouth of the bottle. When the bottle is full of gas, continue to hold the sodium under water till the action ceases. Then cover the bottle with a glass plate and remove from the water. Bring a flame to the bottle and uncover it. Explain the results.

5. What is the gas? Where did it come from? Why was the flame colored yellow in this case? Now explain the flame when potassium was thrown on the water.

6. What method of preparing hydrogen is shown by this experiment? What is one of the elements in water?

7. Test the water with pink litmus. What is dissolved in the water? Write a word-and-symbol equation to show what has taken place.

B. By the Action of the Electric Current on Water.

1. Fill a clean Hoffman apparatus with pure distilled water. Connect the platinum terminals with an electric battery. Is a gas given off at either terminal? Does pure water conduct an electric current?

2. Fill the Hoffman apparatus with water containing 10 per cent of sulfuric acid, so that the water in the reservoir tube stands a short distance above the gas tubes after the stop-cock in each has been closed. Connect the platinum terminal wires with the battery. Allow the current to operate until the smaller volume of gas is from 8 to 10 cm. in height. Measure the height of each gas column.

3. Hold a glowing splint over the tube containing the smaller quantity of gas. What is the gas that collects at the positive electrode (anode)? Open the other stop-cock to force out the water in the glass tip, then hold a lighted match at the end of the tip. What is the gas that collects at the negative electrode (cathode)? Make a drawing showing the anode and cathode and the relative volume of gases collected over each.

4. If the current were allowed to flow long enough, all the water would be used up. The sulfuric acid would remain.

What is the use of the sulfuric acid? Could any other substance have been used?

5. What does this experiment show about the composition of water? Write the word-and-symbol equations to show what takes place on the electrolysis of water.

6. In what three ways may hydrogen be prepared?

7. In what four ways have you prepared oxygen?

III. WATER

EXPERIMENT 11

(Class Experiment)

The Synthesis of Water

MATERIALS. Calcium chloride, copper oxide, wire form.

APPARATUS. Hydrogen generator, calcium chloride tube, delivery tube, clay pipestem, bell jar, hard glass combustion tube 7 inches long.

A. Synthesis of Water by Burning Hydrogen.

1. Connect a calcium chloride tube with a hydrogen generator (a Kipp generator is best). How is the hydrogen generated? Why is the calcium chloride tube used? All joints must be air-tight. Attach a delivery tube to the calcium chloride tube, and collect a test tube full of hydrogen by displacement of water. If it burns quietly, remove the delivery tube and attach a platinum jet or a clay pipestem jet. Why test the gas before it is lighted? Allow the hydrogen to pass for a full minute and then hold a bell jar over the tip. Note any change.

2. Remove the jar, light the hydrogen, and again hold the bell jar over the jet. Note any change in the jar.

3. What is formed when hydrogen burns in the air? Of what elements is water composed? Write the word-and-symbol equation to show the change that takes place.

B. Reduction and Oxidation.

1. Use the same apparatus as in **A.** Attach to the calcium chloride tube a straight glass tube and extend this into a hard-glass test tube containing 1 gram of copper oxide, wire form.

2. When the apparatus is free from air, heat the copper oxide, being careful not to heat the top of the test tube.

3. What change takes place in the copper oxide? What collects on the cool sides of the test tube? Write the word-and-symbol equation for the change that took place.

4. When oxygen or other non-metal is removed from a substance, it is called *reduction.* Is hydrogen a good reducing agent in this case? Why? Yes.

5. When oxygen or other non-metal is *added* to a substance, the process is called *oxidation.* Is copper oxide an *oxidizing agent* in this case? Why?

6. What is meant by the word *synthesis?* In what two ways was water *synthesized* in this experiment?

EXPERIMENT 12

How to Test Hydrogen and Water

MATERIALS. Pine splint, sugar, corn starch, alum crystal, crystals of sodium carbonate, crystalline calcium chloride, potato, meat, apple.

APPARATUS. Bunsen burner, cold glass plates, test tubes.

A. Test for Hydrogen in Substances.

From Experiment 11 you learned that when hydrogen is burned in the air, it combines with the oxygen of the air to

form water. If then water is formed when a substance is burned in air, the substance must contain hydrogen.

1. Light the Bunsen burner. Hold a cold dry glass plate over the flame. Note any moisture on the plate. yes Does ordinary gas contain hydrogen? Now explain why the cold bottom of a kettle or a cold flatiron becomes moist when they are first placed over a flame. Why does the moisture disappear after a time?

2. Why does the inside of a kerosene lamp chimney become covered with moisture when the lamp is first lighted? This moisture disappears in a few minutes. Why?

3. Burn a pine splint and hold a cold dry plate above the flame. Does wood contain hydrogen? yes

B. Test for Hydrogen and Oxygen in Substances.

Some substances contain both hydrogen and oxygen. When these substances are heated till they decompose, the hydrogen in the substance combines with the oxygen in the substance to form water. The substance must *not* be burned. This test proves the presence of both hydrogen and oxygen in a compound.

1. Heat 5 grams of sugar in a dry test tube till it is completely decomposed. Keep the neck of the tube as cold as you can and look for drops of water on the sides of the tube. What are two elements in sugar? In what proportion are these elements present in sugar? Does sugar contain water? What remains in the test tube? Write a word-and-symbol equation for the reaction that took place.

2. In like manner heat 5 grams of corn starch. Explain what takes place. Write the word-and-symbol equation.

C. Test for Water in Substances.

Many substances contain *water* held in such a way as to give the substance its form. Water so held may be removed by heating the substance gently without burning it or decomposing it.

1. Heat a crystal of alum in a dry test tube. Is water given off? yes What happens to the crystal? goes to powder gives off water of crystallization

2. Heat a crystal of sodium carbonate (washing soda) in the same way. Result? gives off water. When crystals of sodium carbonate are exposed to the air they give up water to the air and they fall to a powder. What is this process called? Would it be cheaper to buy clear crystals of washing soda or to buy the substance after it has become a powder from long standing in the air? Why? water given off.

3. Heat a crystal of calcium chloride in a dry test tube. Result? water given off. Now leave exposed to the air some calcium chloride which has been so heated. Result? Explain: went back to original condition. Why does ordinary table salt sometimes become moist and hard to shake from the salt cellar? H_2O absorbed What is sometimes added to prevent this? starch added.

4. Nearly all foods and substances of plant and animal life contain water. Heat in a cool dry test tube portions about the size of a bean of the following substances. Be careful not to burn or decompose the substances.

1. Wood
2. Potato H_2O given off.
3. Meat for all
4. Apple
5. Nut

What do you conclude about the general distribution of water? H_2O everywhere.

EXPERIMENT 13

The Solvent Power of Water

Note to teacher: To avoid repeated weighings small measures may be made out of glass tubing (not too small inside diameter) sealed at one end. Weigh out the required amount of the substance. Jar it into the closed end of the tube and cut off the portion filled with the substance. Place about this a strong gummed label bringing the ends together for a handle.

MATERIALS. Bottles of soda water (one bottle for each four students), alcohol, kerosene, carbon disulfide, powdered copper sulfate, sodium thiosulfate.

APPARATUS. Beaker screen, test tubes, thermometer.

A. **Solubility of Gases.**

Note: Four students may use one bottle of soda water.

1. Remove the cap from a bottle of soda water. What causes the bubbling or the effervescence? How is the pressure on the liquid in the bottle changed when the cap is removed from the bottle? How does change of pressure affect the solubility of a gas?

2. Pour one fourth of a bottle of soda water into your beaker (each student alone). Set this on a wire screen on the ring stand and warm with the burner. Do not heat to a boiling point of water. Why? How does the rise in temperature affect the solubility of a gas?

Throw away the soda water and half fill the beaker with cold water from the faucet and warm it over the burner. Explain the appearance of small bubbles on the inside of the beaker. air

If a glass of ice water is allowed to stand, bubbles appear clinging to the inside of the glass. Give your explanation of this phenomenon.

B. Solubility of Liquids. (*No flames.*)

1. Half fill a test tube with water. Add 5 cc. of alcohol. Shake and look for layers. no layers If a liquid does not dissolve in water, it will form a layer above it if it is lighter than water, or below it if it is heavier than water. Does alcohol dissolve in water? yes.

2. Repeat (1), using kerosene. Will it dissolve? no Is it lighter or heavier than water? lighter than water

3. Repeat (1), using carbon disulfide. Will it dissolve? no Is it lighter or heavier than water? heavier than water

C. Solubility of Solids. (**Instructor's Experiment.**)

1. Put exactly 50 cc. of water in a beaker and add 1-gram portions of powdered copper sulfate as long as it will dissolve; that is, as long as the solution is unsaturated. Stir constantly to aid solution. When no more will dissolve, the solution is *saturated.* Note the temperature. How much copper sulfate will dissolve in a cubic centimeter of water at this temperature? This is the solubility of copper sulfate for that temperature.

2. Heat the saturated solution of copper sulfate over a Bunsen burner flame and add powdered copper sulfate again in 1-gram portions until no more will dissolve. Note the temperature. What is the solubility of copper sulfate at this temperature? How does the rise in temperature affect the solubility of copper sulfate? takes more

3. Cool the solution by allowing cold water to flow over the beaker. Explain.

4. Repeat the experiment, using some other salt in place of copper sulfate. Does the rise in temperature increase the solubility of all substances alike?

5. Heat fifty or sixty grams of sodium thiosulfate crystals in a large test tube until they dissolve in the water they contain, forming a *saturated* solution. Without shaking the tube cool it in running water. Then the solution is *supersaturated* at this temperature, yet no crystals of sodium thiosulfate appear. Now add a crystal of the salt and note the sudden formation of crystals and the rise in temperature.[1]

6. Given a solution of salt how would you prove that it was unsaturated, saturated, or supersaturated?

EXPERIMENT 14

Boiling Point and Freezing Point of Water

Thermometers

Materials. Ice, salt.

Apparatus. Two-hole rubber stopper, short glass elbow, centigrade and Fahrenheit thermometers, flask and screen, test tube, beakers.

A. Boiling Point of Water.

1. Fit the two-hole rubber stopper with a centigrade thermometer and a short glass elbow.

Note: Wet the thermometer and tube before inserting and twist them into place — do not try to push it in or you may break your thermometer and cut your hand. Insert the stopper in a flask containing about 100 cc. of pure water. If the thermometer is not immersed in the water, remove the stopper and push the thermometer further through until it is immersed when the stopper is replaced.

2. Clamp the flask carefully on the ring stand over the ring and wire screen. Heat the water till it boils and note

[1] This principle is made use of in certain "waterless hot water bottles" on the market. These bottles are metal and filled with sodium thiosulfate crystals. If put into boiling water for ten minutes, the crystals dissolve. The bottle will then remain hot for some hours

the temperature when it becomes constant. Apply more heat by turning up the flame. Does the temperature change? Explain.

3. What is the boiling point of water on the centigrade scale?

4. Now raise the thermometer out of the water so that it will be in the steam only as the water boils. Boil the water and note the temperature of steam. Explain.

5. Obtain a Fahrenheit thermometer and repeat the experiment. What is the boiling point of water on this scale?

6. Replace the centigrade thermometer in the stopper. Add ten grams of table salt to the water. Shake until it dissolves. Note the boiling point. How does salt dissolved in water affect its boiling point?

B. Freezing Point of Water.

1. Put some pieces of ice in your 150 cc. beaker and add about 25 cc. of water. Carefully stir the mixture with the centigrade thermometer until the temperature is constant. What is the melting point of ice, centigrade scale?

2. Repeat, using a Fahrenheit thermometer. What is the melting point of ice, Fahrenheit scale?

3. Make a freezing mixture in your 250 cc. beaker by mixing three parts of cracked ice with one part of common salt. Why is the temperature of such a mixture below the freezing point of water?

Half fill a test tube with pure water and place the tube in

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or as long as a real hot water bottle would remain hot, for it cools down slowly from 100° C. to room temperature. The solution is then supersaturated, and if the stopper of the bottle is removed and a wire thrust into the liquid, crystals will form and heat will be given off for several hours longer.

the freezing mixture. Note the temperature, centigrade scale, at which the water begins to freeze. How does the freezing point of water compare with the melting point of ice?

C. Problems in Temperature.

1. Note the room temperature on the centigrade thermometer. F = 69°

From the formula $F. = \frac{9}{5} C. + 32$ (see Appendix) calculate the temperature of the room on the Fahrenheit scale. Now read the Fahrenheit thermometer hanging in the room.

2. On a very warm day the temperature may be 98° F. What would this be on the centigrade scale? Use the formula $C. = \frac{5}{9}(F. - 32)$. (See Appendix.)

3. The normal temperature of the human body is 98° F. In fever cases the temperature may run up to 106° F. What would these temperatures be on a centigrade thermometer?

4. The hottest part of the Bunsen flame is 860° C. What would this temperature be on the Fahrenheit scale?

5. Alcohol boils at 78° C. and solidifies (freezes) at −130° C. What would these temperatures be on the absolute scale? (See Appendix.)

EXPERIMENT 15

How to Purify Water

MATERIALS. Distilled water, salt, bone black, dirt, potassium permanganate solution.

APPARATUS. Watch glass, screen, funnel, filter paper, one round-bottomed distilling flask, a Florence flask, condenser.

A. How to Show the Presence of Salts Dissolved in Water.

1. Put a few drops of distilled water on your watch glass. Place this on the wire screen and slowly evaporate it by

moving the flame back and forth below it. Is there a residue? no

2. Now place a few drops of faucet water on the glass and evaporate. A residue indicates something dissolved in the water. Does the city water contain dissolved salts? yes

3. What other impurities besides dissolved salts may a water contain? any soluble substance.

B. Impurities Removed by Filtration.

1. To some water add dirt, some table salt, and some potassium permanganate to give it color. Place a filter in a funnel and into this pour a thin paste of bone black and water. When this has settled, pour on to it some of the turbid, salty, colored water. Is the turbidity removed? yes Is the color removed? no Is the salt removed? no Test this by evaporating a few drops on a watch crystal as before. no Would dangerous germs or poisonous organic matter be removed? no

2. What impurities are removed by filtration?

C. Impurities Removed by Distillation. (Instructor's Experiment.)

1. Place about 100 cc. of the same turbid water in a round-bottomed distilling flask and connect the flask to the condenser. Why should the water enter the lower opening of the condenser jacket? The water flows out of the upper opening through a rubber tube to the sink. Heat the flask over a screen until the water boils. The steam from the boiling water is condensed in the cool condenser tube and collected in a flask. The condensed liquid is called the *distillate.* The process is *distillation.*

2. Note the color and taste of the distilled water. Test for salt by means of the watch glass as before.

3. Where is the salt and coloring matter? What impuri-

ties may be removed by distillation? What impurities may not be removed in this way?

4. Which is the better water to drink, filtered water or distilled water? Give all the reasons that you can for your answer.

5. What is the source of the drinking water in your city? What impurities are present in this water? What attempts, if any, are made by the city to remove them? How could you make the water more fit for drinking purposes at home?

EXPERIMENT 16

Properties of Hydrogen Peroxide

MATERIALS. Hydrogen peroxide, litmus paper, manganese dioxide, dark hair, ammonium hydroxide.

APPARATUS. Large test tube, splint, filter paper funnel.

A. Properties of Hydrogen Peroxide.

1. What is the formula of hydrogen peroxide? How does it differ in composition from water?

2. What is the hydrogen dioxide sold by druggists?

3. Place 5 cc. of hydrogen peroxide in a large test tube. Test with a small piece of litmus paper. Explain.

4. Add 2 grams of powdered manganese dioxide. Thrust a glowing splint into the tube. What gas is given off? Write the equation. Filter the mixture remaining in the tube. What is the residue? What was the purpose of the manganese dioxide?

5. Why should bottles of hydrogen peroxide be kept tightly stoppered? Why are the bottles always dark in color?

6. Why are the corks of the hydrogen peroxide bottles so white?

B. Uses of Hydrogen Peroxide.

1. Wash some dark hairs free from oil, then immerse them for one hour in 10 cc. of hydrogen peroxide made alkaline with ammonium hydroxide. Remove them and allow them to dry. Result? Hydrogen peroxide is used to bleach wool and silk.

2. Give some of its uses as a disinfectant.

IV. NITROGEN AND THE AIR

EXPERIMENT 17

Preparation and Properties of Nitrogen

MATERIALS. Phosphorus, charcoal, pine splints, 4 g. ammonium chloride, and 8 g. sodium nitrite mixed.

APPARATUS. Wide-mouthed bottle, cover glasses, glass pneumatic trough, 250 cc. flask, one-hole stopper, delivery tube, troughs, 2 gas bottles, ring stand, gauze.

A. Nitrogen from the Air. (Instructor's Experiment.)

Nitrogen and oxygen are the chief gases of the air. If phosphorus is burned in a bottle of air, it will combine with the oxygen, forming phosphorus pentoxide. If there is water in the bottle, the phosphorus pentoxide will dissolve in the water and nitrogen will be left in the bottle.

1. Pin a piece of phosphorus about the size of a pea to a piece of charcoal. Float the charcoal on the water in the glass trough. Light the phosphorus and quickly cover it with a large, wide-mouthed bottle. Keep the neck of the bottle pressed well down into the water. With what was the bottle filled when it was placed over the burning phosphorus? What is the "smoke" that is formed as the

phosphorus burns? What constituent of the air is being removed?

2. Allow the bottle to stand till the "smoke" has dissolved in the water and the gas in the bottle is clear, then make the water level the same inside as outside the bottle. Why has the water risen in the bottle? The gas remaining is chiefly nitrogen. About what part of the air is nitrogen?

3. Cover the mouth of the bottle with a glass plate and invert, taking care not to lose any of the water that has risen in the jar. What are the physical properties of nitrogen in the jar? What are the physical properties of the nitrogen in the air? Is the nitrogen in the bottle pure? Why?

4. Thrust the burning splint into the bottle of nitrogen. Result? Repeat, using phosphorus. Result? Does it burn? Does nitrogen support combustion?

B. Preparation of Pure Nitrogen. Note: Instructor's Experiment, unless Class Is Very Small.

1. Obtain a mixture of 4 grams of ammonium chloride and 8 grams of sodium nitrite. Place this in a 250 cc. flask and add 25 cc. of water. Fit a one-hole rubber stopper and a delivery tube to the flask in order that the gas may be collected over water as in case of oxygen. Clamp the flask to the ring stand over a wire gauze and heat very gently by moving the burner about with the hand. As soon as action begins, stop heating. If the action becomes too violent, lower the wire gauze and raise a bowl of water until the flask is immersed in it and cooled.

When the air is expelled from the flask (about one minute), fill two gas bottles with nitrogen.

2. The reaction that takes place in the preparation of pure nitrogen may be expressed in two equations. (1) The

ammonium chloride and the sodium nitrite react to form ammonium nitrite and sodium chloride:

$$NH_4Cl + NaNO_2 \longrightarrow NH_4NO_2 + NaCl$$

(2) The ammonium nitrite then decomposes into water and nitrogen:

$$NH_4NO_2 \longrightarrow 2\ H_2O + N_2$$

Write these two equations for the preparation of nitrogen, naming all substances used and formed.

3. Using one bottle of the gas, note its physical properties, *i.e.* its color, odor, taste.

Is it soluble in water?

Is it heavier or lighter than air? (See Appendix.)

4. Into the other bottle of gas thrust a burning splint.

Does nitrogen burn?

Does nitrogen support combustion?

EXPERIMENT 18

The Composition of the Air

MATERIALS. Phosphorus, splint, limewater, calcium chloride.

APPARATUS. Glass trough, graduated tube 100 cc. or 250 cc., wire, cover glasses, beaker, long glass elbow, test tube, gas bottle.

A. The Per Cent of Nitrogen and Oxygen in the Air. (Instructor's Experiment.)

1. Half fill a glass trough or battery jar with water. Invert into the jar a graduated tube (about 100 cc. or 250 cc.). Adjust so that the water within and without the tube stands at the same level. Why? Note the volume of air in the tube. 48.6

2. Place a piece of phosphorus on the tip of a wire and insert in the tube. Push up the wire till the phosphorus

is in the upper part of the tube. Be careful not to lift the mouth of the tube from the water. P. oxide

What are the white fumes that come from the phosphorus? oxidation of phosphorus What causes the fumes? What gas is being used up? oxygen

3. Allow the apparatus to stand until the next day. Note the position of the water. Why has it risen in the tube? Are white fumes rising from the phosphorus now? Why? What is the gas that remains in the tube?

4. Lower the tube until the water within and the water without the tube stands at the same level. Why? Note the volume of the gas in the tube.

5. Slip a cover glass over the mouth of the tube and remove it from the jar. To further test the remaining gas thrust into the tube a blazing splint. Does the gas burn? Does it support combustion? What is the gas?

6. Record your observations and calculate the per cent of nitrogen in the air, as follows:

(*a*) Volume of air at the beginning of experiment = cc.

(*b*) Volume of nitrogen at the end of the experiment = cc.

(*c*) Volume of oxygen removed by the phosphorus = cc.

Volume of oxygen (*c*)

$$= \text{volume of air } (a) - \text{volume of nitrogen } (b).$$

The per cent of nitrogen by volume in the air is found as follows:

$$\frac{\text{Volume of nitrogen } (b) \times 100}{\text{Volume of air } (a)} = \quad \% \text{ nitrogen}$$

The per cent of oxygen by volume in the air is found in like manner:

$$\frac{\text{Volume of oxygen } (c) \times 100}{\text{Volume of air } (a)} = \quad \% \text{ oxygen}$$

B. Carbon Dioxide in the Air. (Student's Experiment.)

1. Place about 5 cc. of limewater in a clean beaker and leave it exposed to the air until the close of the laboratory period. Note the white crust formed on the surface of the limewater. This proves the presence of carbon dioxide in the air.

2. Through the long glass elbow blow air from the lungs into 5 cc. of limewater in a test tube. Explain results. This is one source of carbon dioxide in the air.

3. Place a burning splint in a bottle of air. In a short time the splint will go out. Why? Remove the splint and quickly cover the bottle with a glass plate. Add 5 cc. of limewater and shake. Results? How does this experiment show another source of carbon dioxide in the air?

4. Name three other sources of carbon dioxide in the air.

5. If animals are constantly exhaling carbon dioxide, why does not the per cent of oxygen greatly decrease and the per cent of carbon dioxide increase as time goes on?

C. Water Vapor in the Air.

1. Place a piece of calcium chloride on a watch glass or in a dry beaker and leave it exposed to the air overnight. (Lock it in your drawer.) In twenty-four hours look at it again. Explain. A substance that will take up water from the air in this way is a deliquescent substance. Such substances are good drying agents.

2. In what other way could you prove the presence of water vapor in the air?

3. What are some of the sources of water vapor in the air?

Ca Cl_2 + NH_4OH

EXPERIMENT 19

Ammonia, NH_3

MATERIALS. Ammonium chloride (10-g. portions), slaked lime (20-g. portions), concentrated hydrochloric acid, red litmus solution, splints, red litmus paper, and blue litmus paper.

APPARATUS. Large test tube, one-hole rubber stopper, long elbow, 4 gas bottles dry, 2500-cc. beaker, cover glasses.

A. Preparation of Ammonia. $NH_3Cl + Ca(OH)_2$

1. Obtain 10 grams of ammonium chloride and 20 grams of calcium hydroxide (slaked lime). Smell of each. Has either an odor? Now mix them well on a paper with a stirring rod and smell again. What is the odor? Put the mixture in the large test tube. Insert the one-hole stopper with the long elbow. Clamp the test tube in the ring stand, with the outlet tube turned up. Heat the test tube gently. Collect three bottles of the gas by inverting the bottle over the tube and holding it there until a drop of hydrochloric acid held on a stirring rod at the mouth of the bottle fumes strongly. Is ammonia heavier or lighter than air? Write the word-and-symbol equation for the reaction that takes place in the preparation of ammonia.

2. Turn the outlet tube down and insert it into a bottle containing about 20 cc. of water. *The tube must not touch the water.* Why? Heat the mixture until no more gas is given off. (While heating, test the properties of the gas collected.)

B. Properties of Ammonia.

1. What is the color and odor of ammonia?

2. Moisten your finger and hold it in the gas. Touch it to the tongue. What is the taste of ammonia? burns sour

3. Fill your large beaker with water and color it with a few drops of red litmus solution. Uncover a bottle of ammonia and quickly thrust its mouth into the water. Hold it in this position for five minutes. Result? Why not collect ammonia over water? dissolves in it ammonia hydroxide

4. Put a few drops of hydrochloric acid in a bottle; cover and shake well. Place it mouth downward over a bottle of ammonia and remove the glass covers. Result? Explain and write the equation. NH4Cl.

5. Thrust a lighted splint into a bottle of ammonia. Does it burn or support combustion?

6. Remove the outlet tube from the bottle containing the liquid. Smell the liquid. Test it with red and with blue litmus. The gas ammonia combined with the water to form ammonium hydroxide. turns red blue

$$NH_3+H_2O \longrightarrow NH_4OH$$

For what purpose is this liquid used in the home? It is commonly called "ammonia." Is this correct? Explain.
Neutral acids – Cleaning.

V. ACIDS, BASES, AND SALTS

EXPERIMENT 20

General Properties of Acids, Bases, and Salts

MATERIALS. Sulfuric acid, hydrochloric acid, nitric acid, acetic acid, crystals of tartaric acid, red litmus paper, blue litmus paper, magnesium ribbon pieces 1 cm. long, sodium hydroxide, potassium hydroxide, ammonium hydroxide, calcium hydroxide solution (limewater), sodium chloride, potassium sulfate, ammonium chloride, sodium carbonate, phenolphthalein, methyl orange.

APPARATUS. Test tubes, stirring rod, splints.

1 - CO_2 H — O
2 - H
3 H 4 - H + CO_2
5 H + CO_2

A. General Properties of Acids.

1. Half fill five clean test tubes with water. To the first add 3 drops of concentrated sulfuric acid, H_2SO_4; to the second add 3 drops of hydrochloric acid, HCl; to the third add 3 drops of nitric acid, HNO_3; to the fourth add 3 drops of acetic acid, $HC_2H_3O_2$; in the fifth dissolve a crystal of tartaric acid, $H_2C_4H_4O_6$.

2. Dip the clean stirring rod into the dilute sulfuric acid and carefully taste a drop of it. Rinse the mouth with water after tasting. Wash the rod and dip it into the dilute solution of hydrochloric acid and taste a drop of it. Repeat, using nitric, acetic, and tartaric acids. What is the characteristic taste of acids? Sour - acid

3. In each tube place a very small piece of red and of blue litmus paper. What effect have acids on litmus? Empty the tubes and prepare solutions of the acids as in (1). To each tube add a drop of methyl orange. Note result in each case. orange, went red.

Note: Litmus and methyl orange are called *indicators* because by their characteristic color reactions they indicate the presence of acids. By giving a different color they may also be used to indicate the presence of bases, as will be shown later.

4. Place about 10 cc. of each acid in separate clean test tubes and add to each (one at a time) a piece of magnesium ribbon about 2 cm. long. Cover the tube with the hand, or a piece of cardboard, for about a minute or until effervescence ceases; then test the gas in the tube with a burning splint. What is the gas? Where does it come from? Write the word-and-symbol equations for the reactions that take place in each case. Do acids dissolve other metals? yes

5. Write in a vertical column, one under the other, the names and formulas of the five acids you have studied.

Compare the formulas. In what respect are the acids similar in composition?

6. Define an acid as completely as you can.

7. What are the chief acids formed in vinegar? lemon juice? sour milk? (See textbook.)

B. General Properties of Bases.

Note to student: An hydroxide (sometimes called hydrate) is composed of a metal or metallic radical combined with one or more hydroxyl radicals. Most of the hydroxides are insoluble. A few are soluble; these are called *bases* and they possess properties in common, as will be noted below.

1. In four different test tubes obtain 10 cc. of sodium hydroxide, NaOH, potassium hydroxide, KOH, ammonium hydroxide, NH_4OH, and calcium hydroxide, $Ca(OH)_2$, respectively. Label the tubes.

2. Taste the calcium hydroxide. Do not taste the others without diluting greatly — about one drop in a half test tube of water. Describe the taste of the bases.

3. Drop a small piece of pink and of blue litmus in each tube. Results? all go blue Test fresh solutions of each with a drop of methyl orange. Result in each case? Test fresh solutions of each with a drop of phenolphthalein. Result in each case? goes red.

4. Rub a little of each solution between the fingers. Describe the feeling. slick — like soap

5. Write in a vertical column, one under the other, the names and formulas of the four bases you have studied. Compare the formulas. In what respect are the bases similar in composition?

6. Define a base as completely as you can.

7. What is the chief hydroxide in "limewater"? "household ammonia"? "Red Seal lye"?

C. General Properties of Salts.

1. In separate test tubes obtain about one gram of sodium chloride, NaCl, potassium sulfate, K_2SO_4, ammonium chloride, NH_4Cl, and sodium carbonate, Na_2CO_3. Label the tubes.

2. Half fill the tubes with water; shake and warm until the salts dissolve. Taste each solution. Do they taste like acids or bases? Rinse your mouth. salty

3. Place in each tube a piece of red and of blue litmus paper.

What effect have salts such as sodium chloride and potassium sulfate upon litmus? no effect weak base

2. a Explain briefly why solutions of salts such as ammonium chloride turn litmus red. (See hydrolysis in text.) Why do solutions of salts like sodium carbonate turn litmus blue? SB - WA

4. Rub a solution of each salt between the fingers. Do they feel slippery? no

5. Write the names and formulas of the salts in a vertical column, one under the other. Compare the formulas.

6. Define a salt as completely as you can.

7. What is ordinary "table salt"? "baking soda"? "washing soda"? "saltpeter"? NaCl NaCO$_3$
NaHCO$_3$

D. Litmus Reaction of Common Substances.

Note: These tests are to be made at home.

1. Take home five or six strips of red and of blue litmus paper and test the following substances with a portion of each strip. Dissolve solids in water before testing. Tabulate the reaction toward litmus under the following heads:

Acid Reaction	Basic Reaction	Neutral Reaction

Test: Borax, soap, faucet water, tooth powder, pickle, cream of tartar, washing soda, sour milk, sweet milk, vinegar, lemon juice, ripe fruits, green fruits, sugar, and olive oil.

EXPERIMENT 21

Methods of Forming Acids, Hydroxides, and Salts

Note: Two double laboratory periods will probably be required for this experiment.

MATERIALS. Sodium, filter paper, solution of phenolphthalein, lime, copper sulfate, ferric chloride and magnesium chloride (solution), sodium hydroxide, hydrochloric acid, magnesium ribbon, red phosphorus, sulfur, sodium chloride.

APPARATUS. Evaporating dish, glass plate, red litmus paper, blue litmus paper, small beaker, funnel, asbestos paper.

A. Methods of Forming Acids.

1. Action of non-metallic oxides on water.

Note: A non-metallic oxide which when dissolved in water will produce an acid is called an acid anhydrid.

(*a*) In the combustion spoon place a small piece of asbestos paper and on it a little sulfur. Ignite the sulfur in the Bunsen flame and lower the spoon into a bottle of air, covering the bottle as far as possible with a glass plate. When the action ceases, remove the spoon. What is in the bottle? SO_2 Write the word-and-symbol equation for the reaction. $S + O_2 \to SO_2$

Now add about 5 cc. of water and shake thoroughly. Test the liquid with both red and blue litmus. acid B-R. Result? H_2SO_3 What acid has been formed? Write the word-and-symbol equation. $H_2O + SO_2 \to H_2SO_3$ sulfurous acid

(*b*) Reline the spoon with asbestos and repeat (*a*), using a small amount of red phosphorus (about the size of a kernel of wheat). What is the oxide formed? Phosphorous oxide Write the word-and-symbol equation. Add water; shake and test with litmus. Result? B-R. What is the acid formed? Phosphorous acid Write the word-and-symbol equation.

$4P + 3O_2 \to 2P_2O_3$ - Phosphorous oxide.

$P_2O_3 + 3H_2O \to 2H_3PO_3$ - Phosphorous acid.

(*c*) When carbon dioxide is dissolved in water, carbonic acid is formed. Write the word-and-symbol equation to show the reaction. $H_2O + CO_2 \rightleftarrows H_2CO_3$

(*d*) What oxide is the anhydrid of sulfuric acid? Write the word-and-symbol equation. $SO_3 + H_2O \rightarrow H_2SO_4$

2. Action of an acid with a higher boiling point on the salt of the acid desired.

Note: Sulfuric acid has a much higher boiling point than the common acids, such as hydrochloric, nitric, and acetic acids, so that it is generally used in the preparation of these acids on a large scale.

(*a*) Place about 5 grams of sodium chloride in a test tube and add 5 cc. of concentrated sulfuric acid. Warm gently and cautiously. Note the odor of the gas evolved. Test the gas with strips of red and of blue litmus moistened. Result? This gas is hydrogen chloride or hydrochloric acid gas. Write the word-and-symbol equation for the reaction.

$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$

Note: This method will be given in detail later. See Experiment 22.

(*b*) Write the word-and-symbol equation for the reaction between sodium nitrate and sulfuric acid to form nitric acid.

$2 NaNO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2 HNO_3$

B. Methods of Forming Hydroxides.

1. Action of metallic oxides on water.

Note: A metallic oxide which when dissolved in water will produce a base is called a base anhydrid.

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(*a*) What is lime? How is it formed?

(*b*) Obtain about 5 grams of lime. Place it in your small beaker and add 10 cc. of water. Stir for about 5 minutes, then filter. What is the residue on the filter paper? What is in the filtrate? Write a word-and-symbol equation to show what is formed when calcium oxide is added to water. Rub some of the solution between the fingers. Taste it.

$Ca(OH)_2 \rightleftarrows CaO + H_2O$

R — B goes Red

Test it with litmus and phenolphthalein. Note results in each case. Write the word-and-symbol equation for the reaction. Is calcium hydroxide as soluble as sodium hydroxide?

2. Action of metals on water. (*Instructor's Experiment.*)

(*a*) Place on a piece of filter paper a piece of sodium about as large as a pea. Half fill your evaporation dish with water. Have a glass plate ready to cover it. Drop the sodium on the water and cover the dish with the glass plate. Note what takes place. (Recall Experiment 10.)

When the action is over, rub some of the solution between the fingers. Result? Taste it carefully. Result? Test with pieces of red and of blue litmus. Result? Add a drop of phenolphthalein solution. Result?

What substance is contained in the water?

Write a word-and-symbol equation to show its formation from the sodium and water.

(*b*) Potassium hydroxide could be prepared in the same way, using potassium instead of sodium. Write the word-and-symbol equation to show what would take place.

Are potassium and sodium hydroxides soluble or insoluble?

3. Insoluble hydroxides.

In three separate test tubes obtain 5 cc. of solutions of the salts, copper sulfate, ferric chloride, and magnesium chloride. Fill each test tube half full of water and add 1 cc. of sodium hydroxide to each tube. What is formed in each case? Write the word-and-symbol equation to show what was formed in each case.

Insoluble hydroxides do not feel slippery. They have no taste. They do not affect litmus. They *do* react with acids to form salts as soluble hydroxides do.

$NaOH + CuSO_4 \rightarrow NaSO_4 + CuOH$
$NaOH + FeCl \rightarrow FeOH + NaCl$
$NaOH + MgCl \rightarrow MgOH + NaCl$

C. Methods of Forming Salts.

1. By neutralization — the action of an acid on a base.

Place 10 cc. of sodium hydroxide, NaOH, in a beaker and add a drop of phenolphthalein. Then add hydrochloric acid, HCl, till the color just disappears. Rub some of the solution between the fingers. Taste it. Test it also with red and with blue litmus. Is an acid present? Is a base present? What has been formed? Evaporate 10 cc. of the solution to dryness in the evaporation dish. Taste the solid. Why is this process called neutralization? Write the word-and-symbol equation. NaOH + HCl → NaCl + H_2

2. By the action of acids on metals.

Recall the action of sulfuric acid, H_2SO_4, on zinc in the preparation of hydrogen in Experiment 9. Write the word-and-symbol equation for the reaction. $H_2SO_4 + Zn \rightarrow ZnSO_4 + H_2$

Add some hydrochloric acid, HCl, to about an inch of magnesium ribbon in a test tube. What gas is liberated? H. When the action ceases, evaporate some of the liquid to dryness. What salt was formed? Write the word-and-symbol equation for the reaction. $2HCl + 2Mg \rightarrow 2MgCl + H_2$

Note: The instructor may perform the following experiments or merely discuss them in class.

3. By the action between elements.

When iron is heated with sulfur, iron sulfide, FeS, is formed. Write the word-and-symbol equation.

Also when copper reacts with chlorine, copper chloride, $CuCl_2$, is formed.

Write the word-and-symbol equation.

When zinc dust (2 parts) and sulfur (1 part) are mixed and heated, zinc sulfide, ZnS, is formed.

4. By the action of acids on oxides.

Magnesium oxide, MgO, reacts with hydrochloric acid, HCl, to form magnesium chloride, $MgCl_2$, and water.

Write the word-and-symbol equation.

5. From another salt when a gas is formed.

The salt potassium chlorate, $KClO_3$, when heated will give a new salt, potassium chloride, KCl, and oxygen.

Write the word-and-symbol equation.

6. From another salt when an insoluble substance is formed.

If a solution of the salt barium chloride, $BaCl_2$, is added to a solution of sodium sulfate, Na_2SO_4, two new salts are formed — one insoluble salt, barium sulfate, $BaSO_4$, and one soluble salt, sodium chloride, $NaCl$.

Write the word-and-symbol equation.

EXPERIMENT 22

(Class Experiment)

Solutions That Conduct the Electric Current

MATERIALS. An electric lighting current, distilled water, about half normal solutions of hydrochloric acid and sulfuric acid and acetic acid, sodium hydroxide, ammonium hydroxide, sodium chloride, zinc sulfate, sugar, alcohol, concentrated sulfuric acid.

APPARATUS. A lamp block with a 16 candle-power lamp, an electric cell consisting of a tall 10-cc. beaker and 2 platinum or carbon electrodes.

Note: If the solution of a substance in water will conduct the electric current, the substance is called an electrolyte.

If it will not conduct a current it is a non-electrolyte.

A. **Conducting Power of Pure Water.**

1. Connect an electric lighting current in series with a 16 candle-power electric lamp and cell consisting of a small beaker

and two carbon electrodes. The lamp cuts down the current strength and indicates the passing of a current by lighting.

2. Pour distilled water into the beaker until the electrodes are completely immersed. Does the lamp glow? Will pure water conduct the electric current?

B. Conducting Power of Concentrated Sulfuric Acid.

1. Immerse perfectly dry electrodes in a cell of concentrated sulfuric acid. Does the lamp glow? Will pure concentrated sulfuric acid conduct the electric current?

C. Conducting Power of Solutions of Acids.

1. Dissolve one drop of sulfuric acid in the distilled water in the cell. Does the lamp glow? Will a water solution of sulfuric acid conduct the electric current? Is sulfuric acid an electrolyte?

2. Remove and wash the electrodes and replace the solution of sulfuric acid with a dilute solution of hydrochloric acid. Result?

3. Remove and wash the electrodes and replace solution of hydrochloric acid with a solution of acetic acid. Does the lamp glow as brightly as in (1) or (2)? Does the acetic acid conduct the current as well as hydrochloric acid? The action of these acids is characteristic of nearly all acids. Acids in water give ions. The ions carry the current. What ions does sulfuric acid give? What ions does hydrochloric acid give? What ions does acetic acid give? What ions do all acids give? Some substances in solution give more ions than others. The one that gives the most ions conducts the current best. The acid that gives the most hydrogen ions is the strongest acid (the concentrations being the same).

Which of the three acids above are strong? which weak?

D. Conducting Power of Solutions of Bases.

1. Replace the acid solution by a solution of sodium hydroxide. Result? Is sodium hydroxide an electrolyte?

2. Repeat, using ammonium hydroxide. Does the lamp glow as brightly as (1)? Does ammoni m hydroxide conduct the current as well as a solution of sodium hydroxide?

What ions does sodium hydroxide give?

What ions does ammonium hydroxide give?

What ions are common to all bases?

The base giving most hydroxyl ions is the strongest (the concentrations being the same in each case). Which is the stronger base, sodium hydroxide or ammonium hydroxide?

E. Conducting Power of Solutions of Salts.

1. Place in the beaker a solution of sodium chloride. Result? What ions does sodium chloride give in solution?

2. Repeat, using a solution of zinc sulfate. Result? What ions does zinc sulfate give in solution? In general, what ions do all the more common salts give in solution?

F. Conducting Power of Non-electrolytes.

1. Place in the beaker a solution of sugar. Does it conduct the electric current? Why?

2. Repeat, using a solution of alcohol. Does it conduct the current? Why?

Questions

1. What electrolytes did you study in this experiment?
2. What non-electrolytes did you study?
3. Define an acid, a base, and a salt with reference to the ions they give in solution.
4. Define a strong acid.
5. Define a concentrated acid.

VI. THE HALOGENS AND HYDROCHLORIC ACID

EXPERIMENT 23

Chlorine, Bromine, and Iodine

MATERIALS. Bleaching powder (fresh), 4 N sulfuric acid, strips of colored calico, white cloth, colored flowers, potassium iodide, potassium bromide, starch paste, and alcohol.

APPARATUS. 500-cc. Florence flask, stopper, thistle tube, delivery tubes, gas bottles, 250-cc. Florence flask, test tubes, and beaker.

Caution: Chlorine is poisonous. The instructor usually performs the experiment.

A. Preparation of Chlorine.

1. Place 50 grams of bleaching powder (chlorinated lime) in a 500 cc. Florence flask. To the flask fit a stopper containing a thistle tube and a delivery tube. The delivery tube should extend to the bottom of a dry bottle covered with cardboard. The gas is heavier than air and may be collected by displacement of air.

Through the thistle tube add about 50 cc. of 4 N sulfuric acid. If necessary, warm the flask gently. Collect four bottles of the gas and cover them with glass plates. Complete the equation, naming the substances:

$$CaOCl_2 + H_2SO_4 \rightarrow$$

B. Properties of Chlorine.

1. Extend the delivery tube into the bottle half filled with water. Does chlorine dissolve in water?

2. Note the color of chlorine gas, and very *carefully* note its odor by wafting to the nose by the hand.

3. In another bottle suspend a strip of moist calico and a strip of dry, colored calico. Explain the water's action.

4. In another bottle place violets or a carnation. Result?

5. In the fourth bottle suspend a strip of moist white cloth having an ink stain. Result?

6. Into the "chlorine water" prepared in (1) place a strip of white goods having an ink stain.

7. Explain the use of bleaching powder (chlorinated lime) in removing stains and in bleaching goods, and as a disinfectant.

C. Preparation and Properties of Bromine.

1. Place 5 grams of powdered potassium bromide and 3 grams of manganese dioxide in a 250 cc. Florence flask. Add 20 cc. of 4 N sulfuric acid. Warm if necessary. Write the equation for the preparation.

2. Note the color and the odor of the bromine gas. At an ordinary temperature bromine is a liquid. It is the only liquid non-metal. Examine some liquid bromine. Pour a drop of bromine into water. Does it dissolve? Is it heavier or lighter than water?

D. Preparation and Properties of Iodine.

1. Repeat C, 1 using potassium iodide instead of potassium bromide. Write the equation for the preparation of iodine.

2. Note the color of iodine vapor. What collects upon the cold neck of the flask?

3. Examine crystals of iodine. Describe them. Put a crystal in a test tube and heat it. Result? What collects on the sides of the tube? Explain.

4. Try to dissolve a crystal of iodine in water. Result? Pour off the water and add alcohol. The solution of iodine

HCl + AgNO3 = AgCl + HNO3

in alcohol is called "tincture of iodine." What is this used for?

5. To a beaker of water add 1 drop of starch paste and then 1 drop of the tincture of iodine prepared in (4). Result? This is a test for starch.

EXPERIMENT 24

Preparation and Properties of Hydrochloric Acid, HCl

MATERIALS. 30 g. portions of NaCl, 4 *N* sulfuric acid, litmus paper, splints, blue litmus solution, silver nitrate solution, ammonium hydroxide, nitric acid, potassium chloride.

APPARATUS. 250 cc. Florence flask, delivery tubes, gas bottles, large beaker, test tubes, thistle tube.

A. Preparation of the Gas Hydrogen Chloride.

1. Put about 30 grams of sodium chloride (common salt) into your 250 cc. Florence flask. Insert the 2-hole rubber stopper containing the thistle tube and delivery tube. Attach the long delivery tube to the short one and extend it into a dry gas bottle covered with cardboard. Add through the thistle tube about 50 cc. of sulfuric acid and warm gently. Collect 2 bottles of gas hydrogen chloride. The bottles are full when a piece of moist blue litmus paper held at the mouth turns pink. Cover them with about 50 cc. of water, forming hydrochloric acid. Write the word-and-symbol equation for the preparation of the gas hydrogen chloride. NaCl + H2SO4 → HCl + NaHSO4

B. Properties of the Gas Hydrogen Chloride. pungent

1. Note the color and odor of the gas. Is it heavier than air? No No

2. Thrust a lighted splint into one of the bottles. Does hydrogen chloride burn? Does it support combustion?

3. Fill your large beaker with water and add 1 cc. of blue litmus solution. Uncover the second bottle of the gas and invert it quickly in the beaker of water. Explain the result.

C. Properties of Hydrochloric Acid.

1. Remove the delivery tube from the bottle containing the water in which the hydrogen chloride has dissolved, forming hydrochloric acid. Test the liquid with blue litmus paper. Result? Taste a drop of the liquid. Result? What is the hydrochloric acid on your desk?

2. Place 5 cc. of the hydrochloric acid which you prepared in a test tube and add a drop of silver nitrate. What is the white precipitate formed? Write the word-and-symbol equation. Divide the precipitate into two parts. To one part add ammonium hydroxide till the liquid is alkaline. Result? To the other part add nitric acid. Result?

3. Repeat (2), using any soluble chloride instead of hydrochloric acid. Result? Write the equation to show the formation of silver chloride.

State the test for hydrochloric acid and its salts. What is the general method for the preparation of an acid?

VII. SULFUR AND COMPOUNDS OF SULFUR

EXPERIMENT 25

Sulfur and Compounds of Sulfur

MATERIALS. Sulfur, colored goods, a colored flower, sodium sulfite, concentrated sulfuric acid.

APPARATUS. Deflagrating spoons, gas bottle, pneumatic trough, litmus paper, flask, test tubes, safety tube, delivery tube.

A. **Sulfur.**

1. Note the physical properties of sulfur, *i.e.* color, odor, taste.

2. Boil some sulfur in a test tube half full of water. Filter and note that the water is pale yellow. Is sulfur soluble in water?

3. What are some of the uses of sulfur?

B. **Sulfur Dioxide, SO_2.**

1. Place about 20 grams of sodium sulfite in a flask. Insert the stopper with a thistle tube and delivery tube. Add concentrated sulfuric acid through the thistle tube. Warm the flask if necessary. Collect the gas by downward displacement of air. Fill 3 bottles. Write the equation to show the reaction that takes place in this method of preparing sulfur dioxide.

Note: Sulfur dioxide can also be prepared by burning sulfur in the air. Write the equation.

2. Note the physical properties of the gas, *i.e.* the color and odor. Half fill your trough with water and quickly invert one bottle of sulfur dioxide in it. Is sulfur dioxide soluble in water? When the water no longer rises slip a glass plate over the mouth of the bottle and place it right side up on the table. Taste the liquid in the bottle. Test it with red and with blue litmus. What is formed when sulfur dioxide dissolves in water? Write the equation to show the reaction.

3. Into the second bottle thrust a burning splint. Does sulfur dioxide burn or support combustion?

4. Into the third bottle of sulfur dioxide place a strip of moistened colored goods and also a fresh violet or carnation

or other colored flower. This illustrates the use of sulfur dioxide as a bleaching agent for nuts and fruits before they are dried. In this case the sulfur dioxide is prepared by burning sulfur in air.

EXPERIMENT 26

Sulfuric Acid and Hydrogen Sulfide

MATERIALS. Pine splint, concentrated sulfuric acid, sugar, sodium acetate, distilled water, barium chloride solution, hydrochloric acid, and ferrous sulfide.

APPARATUS. Test tubes, flask, delivery tube, safety tube, litmus paper, and splints.

A. **Sulfuric Acid.**

1. Pour 1 cc. of concentrated sulfuric acid into 5 cc. of water in a test tube. (*Caution:* Never pour the water into the acid.) Note the heat produced by touching the bottom of the test tube to the hand.

2. Thrust a pine splint into 5 cc. of concentrated sulfuric acid in a test tube. Warm gently. Remove the splint and note result.

3. To a gram of sugar in another test tube add a few drops of concentrated sulfuric acid. Warm and explain result. Write the equation to illustrate in a general way what took place. Explain why concentrated sulfuric acid causes such serious burns.

4. Half fill a test tube with distilled water, then add a drop of concentrated sulfuric acid. To this add 1 cc. of barium chloride solution. The precipitate is barium sulfate, $BaSO_4$. Try to dissolve the precipitate in hydrochloric acid. Result? In nitric acid. Result? State the test in your own

words. Complete the following equations, naming all substances:

$$H_2SO_4+BaCl_2 \longrightarrow 2HCl + BaSO_4$$

$$Na_2SO_4+BaCl_2 \longrightarrow 2NaCl + BaSO_4$$

B. Hydrogen Sulfide.

1. Set up your flask as a gas generator. In it place 10 grams of ferrous sulfide. Add hydrochloric acid through the safety tube. Collect a bottle of the gas by downward displacement of air. Complete the following equation for the reaction, naming all substances:

$$FeS+2\,HCl \longrightarrow H_2S + FeCl_2$$

2. Note the physical properties of the gas, *i.e.* color, odor.

Note: Let the gas bubble into a test tube of water while you are studying the properties of the gas in the bottle.

3. Thrust a burning splint into the bottle of gas collected. Result? Burned.

The hydrogen sulfide is oxidized to water and sulfur dioxide when it burns. Write the equation for the reaction which takes place when hydrogen sulfide burns in the air.

$$2\,H_2S+3\,O_2 \longrightarrow 2H_2O + 2SO_2$$

Sometimes sulfur is precipitated if the oxidation is incomplete. Write an equation to illustrate this reaction.

$$2\,H_2S+O_2 \longrightarrow 2H_2O + 2S$$

Hydrogen sulfide is a strong reducing agent.

4. Test the solution of hydrogen sulfide prepared in (2) with red and with blue litmus. Result? It is a very weak acid. Put a drop of the solution on a silver coin. Result? Why do silver spoons turn black if used for eating eggs?

5. How would you test for a sulfide?

VIII. CARBON. CARBON DIOXIDE. FLAMES

EXPERIMENT 27

Carbon

MATERIALS. Potato, bread, meat, starch, sugar, cotton, paper, wood, coal, any vegetable, sand, wood charcoal, lampblack, bone black, graphite, coal, sulfuric acid, sodium hydroxide, brown sugar, copper oxide.

APPARATUS. Iron pan, ring stand, test tubes, filter paper, funnel, beaker, hard-glass test tube.

A. Occurrence of Carbon.

1. Place a thin layer of sand in a small iron pan and on it put small pieces of the substances listed above. Cover the materials with sand to protect from the action of the air. Why? Heat until smoking ceases. Cool and examine. What has happened to the substances? What is the black residue?

How is willow charcoal prepared? How is animal charcoal prepared? For what purposes are these substances used?

2. Close the holes in the Bunsen burner; light it and turn it low. This makes a small luminous flame. Hold a cold, dry surface or evaporating dish in this flame. Result? What is this form of carbon called?

How is lampblack prepared? For what purpose is it used? What element is found in the foods we eat and the fuels we burn?

B. Properties of Carbon.

1. In five different test tubes place respectively about 5 grams of wood charcoal, bone black (animal charcoal), graphite, lampblack, coal.

Note the physical properties of each.

Place small portions of each in other test tubes and add some water. Are any of the forms of carbon soluble in water? no

2. Place portions of each in other tubes and add some sulfuric acid or any acid. Result?

Repeat, using sodium hydroxide. Result?

3. Dissolve 20 grams of brown sugar in 100 cc. of water. Note the color of the solution. Add 10 grams of bone black and boil for ten minutes. Filter. Note the color of the filtrate. Taste it. Where is the sugar? If the filtrate is not colorless, add some more bone black; warm and filter again till it is colorless. How is bone black used in sugar refining?

4. In a hard-glass test tube heat for 10 minutes a mixture of 3 grams of powdered wood charcoal with 3 grams of copper oxide. Cool and pour the contents upon a paper. What is the reddish material? What becomes of the charcoal?

Write an equation to show the reducing action of carbon in this case.

EXPERIMENT 28

Carbon Dioxide, CO_2

MATERIALS. Marble chips, dilute hydrochloric acid, splints, limewater.

APPARATUS. Flask, safety tube, stopper, delivery tube, bottles, beaker, test tubes.

A. Preparation of Carbon Dioxide.

1. Place some pieces of marble in your 250 cc. flask. Insert the stopper containing the safety tube and the delivery tube. Add dilute hydrochloric acid through the safety tube, a few centimeters at a time.

2. Collect three bottles of the gas by downward displace-

ment of air. The bottle is full when the flame of a burning splint held at its mouth is extinguished.

3. Write the equation for the reaction between hydrochloric acid and marble in the preparation of carbon dioxide. $CaCO_3 + 2HCl \to CaCl_2 + H_2O + CO_2$

B. Properties of Carbon Dioxide.

1. Note the chief physical properties of carbon dioxide. Test its solubility in water by inserting one of the bottles of the gas in a beaker of water. Let it stand. Does the water rise? Is carbon dioxide soluble in water?

2. Into a second bottle of the gas thrust a burning splint. Result? What use does this suggest for the gas? does not support combustion

3. Prove that the gas is heavier than air by pouring a bottle of it into an empty bottle as if it were a liquid. Test for its presence in the second bottle with the burning splint. Result? tests for CO_2

4. Extend the delivery tube from the generator into 10 cc. of limewater in a test tube and allow the carbon dioxide to bubble through the limewater. What is the white precipitate obtained? Write the equation for the reaction. This is a test for carbon dioxide. test for CO_2

5. Prove that air exhaled from the lungs contains carbon dioxide by blowing some air through 10 cc. of fresh limewater in a test tube. Explain the presence of carbon dioxide in the air exhaled from the lungs.

6. Burn a splint in a bottle. Cover the bottle. Add limewater and shake. Result? Explain.

7. Burn a piece of paper in a bottle. Cover the bottle. Add limewater and shake. Result? Explain. same

8. Any substance which contains carbon will form carbon

dioxide when it burns. The limewater test for carbon dioxide is therefore an indirect test for carbon.

Note: If there is time, perform A, 1 and B, 1 of Experiment 29.

EXPERIMENT 29

Carbonic Acid and Carbonates

MATERIALS. Carbon dioxide generator, sodium hydroxide, sodium bicarbonate, copper carbonate, magnesium carbonate, sodium bicarbonate, hydrochloric or sulfuric acids, limewater, baking soda, washing soda, boiler scale, sea shells, limestone.

APPARATUS. Evaporating dish, test tubes.

A. Carbonic Acid, H_2CO_3.

1. Pass some of the carbon dioxide gas from the generator used in Experiment 28 through 25 cc. of water. The gas combines with the water to form carbonic acid. Write the equation for the reaction. Taste the liquid. Result? Test the acid formed with blue litmus paper. Result?

Now explain what soda water is.

$CO_2 + H_2O \rightarrow H_2CO_3$

B. Salts of Carbonic Acid, the Carbonates.

1. Pass carbon dioxide through 20 cc. of solution of sodium hydroxide in a test tube as long as any gas is absorbed. Pour the solution into your evaporating dish and evaporate to dryness. What substance remains? Write the equation for the reaction. $CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$

2. In labeled tubes obtain 1 gram of sodium bicarbonate, copper carbonate, magnesium carbonate, and sodium carbonate. Note the physical properties of each. Place half of the sodium bicarbonate in another test tube, add 20 cc. of water, warm, and shake. Is sodium bicarbonate soluble in water?

In like manner test the solubility of the other carbonates

mgcl insoluble in H_2O.

you obtained. Make a table showing which of the carbonates tested are soluble in water and which are insoluble.

3. To the other half of the sodium bicarbonate add either dilute hydrochloric or sulfuric acid. Carbon dioxide gas is evolved. Prove this by holding a drop of limewater on a stirring rod in the gas coming from the tube. If the drop becomes milky, carbon dioxide is indicated.

Write the equation for the reaction.

In like manner test the action of an acid on the other carbonates you obtained. Write the equations for the reactions in each case. All carbonates, when treated with hydrochloric or sulfuric acid, evolve carbon dioxide. This is the test for a carbonate.

$NaHCO_3$

4. Test baking soda for a carbonate. What is baking soda?

5. Test washing soda for a carbonate. What is washing soda?

6. Test boiler scale from a teakettle at home for a carbonate. What is boiler scale?

7. Test coral, oyster shell, or any other sea shell for a carbonate. Of what are sea shells composed chiefly?

8. Test limestone for a carbonate. What is limestone?

EXPERIMENT 30

Flames

MATERIALS. Candles, splints, powdered wood charcoal.

APPARATUS. Glass elbow or tube, wire screen, evaporating dish.

A. Candle Flame.

1. Place a lighted candle so that the flame is against a black background and note the different cones in the flame. Draw a diagram showing the different parts of the flame.

3-13-

2. Test the different cones in the flame with a small splint. Which is the hottest cone?

3. Blow out the flame and hold a lighted splint in the little column of smoke coming from the wick. Explain the result.

4. Candle wax is composed chiefly of carbon and hydrogen. What then are the chief products of combustion when a candle burns in the air? Prove the presence of these products by very simple experiments. $C + H + O \to CO_2 + H_2O$

B. Bunsen Flame. calcium carbonate

1. Draw the diagram of a Bunsen flame.

2. Test the different cones in the flame with small splints. Which is the hottest flame? Hold a splint horizontally in the base of the Bunsen flame for three seconds. Explain the result.

3. Put one end of a glass elbow or glass tube in the inner cone just above the burner tube and light the gas at the end of the glass tube. Raise the tube until it is in the Bunsen flame's second cone. Result? What is the inner cone of the Bunsen flame? gas lights —

4. Press the wire screen down in the Bunsen flame. Why does the flame not burn above the screen? Light the gas above the screen. Turn the gas off, then turn it on again and light it above the wire screen held about two inches above the top of the burner. Explain.

5. Shake some powdered wood charcoal into a non-luminous Bunsen flame. Explain the result. Beat some of the chalk dust from a blackboard eraser into a non-luminous flame. Explain the result.

6. Make the Bunsen flame luminous by closing the holes in the tube. Hold a clean, dry evaporating dish in the

all the carbon isn't burned ∴ carbon is deposited

luminous flame. Why is carbon (lampblack) deposited? Will a non-luminous flame deposit soot? What makes a flame luminous?

7. The flame produced by the burner of the kitchen range is non-luminous. Explain how the burner is constructed to produce this non-luminous flame. Draw a diagram.

What advantages has a non-luminous flame over a luminous one in such a range? hotter How could the same gas that is used for lighting purposes in the range be used for lighting the home? By having a luminous flame.

PART II

SECOND TERM'S WORK

IX. COMMON ORGANIC COMPOUNDS

An organic compound is one that contains carbon. Organic chemistry is the study of compounds containing carbon. Carbon monoxide, carbon dioxide, carbonic acid, and the carbonates are organic compounds, but for the sake of convenience, and because of their common occurrence, they are usually studied in inorganic chemistry.

The simplest organic compounds are composed of carbon, hydrogen, and oxygen. The more complex compounds found in plant and animal tissues are composed of carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorus in varying proportions. These complex bodies are usually decomposed when heated, leaving a black residue of carbon. This is called a "charring test" for an organic compound.

Some substances, like kerosene, when heated, burn leaving no residue of carbon. Such substances burn with a luminous flame that deposits "soot," which is carbon, upon a cool surface. This is also a test for an organic substance. This is called the "soot test."

There are other substances, like alcohol and ether, which neither leave a residue nor deposit "soot" when they burn. If a drop of limewater is held over such a flame, the presence of carbon dioxide may be detected. This test holds good for any organic substance, for carbon dioxide is always formed when such a substance burns.

EXPERIMENT 31

Tests for Organic Compounds

MATERIALS. Flour, sugar, salt, baking powder, wood, milk, talcum powder, kerosene, gasoline, paraffine, turpentine, olive oil, lard, ether, limewater, alcohol.

APPARATUS. Bunsen burner, evaporating dish, test tubes, stirring rod.

A. " Charring Test " for an Organic Compound.

1. Heat about 2 grams of flour in an evaporating dish. Note the results. What remains? Heat the black residue strongly. Will it burn? Continue heating till the carbon has entirely disappeared. What is the white ash that remains? Does flour contain organic compounds? Does it contain inorganic compounds? Clean the dish with sapolio.

2. In like manner heat a very small amount of sugar, salt, baking powder, wood, milk, talcum powder. Tabulate your results as follows:

Organic Compounds	Inorganic Compounds	Organic and Inorganic Compounds

B. "Soot Test" for Organic Compounds Which Do Not Char When Heated.

1. Heat in a dry evaporating dish 1 cc. of kerosene until it burns. Is the flame colored? Hold a cold glass plate in the flame. Result? What is the black deposit? Is kerosene an organic compound? Is there a residue?

2. In like manner test gasoline, paraffine, turpentine, olive oil, and lard. State the result in each case.

C. "Carbon Dioxide Test" for Organic Compounds.

1. Heat 1 cc. of ether in an evaporating dish till it burns. Is the flame colored? Hold a cold glass plate over the flame. Does it deposit "soot"? Obtain 5 cc. of clear limewater in a clean test tube. Dip the stirring rod in the limewater and hold the clear drop over the flame. Does the drop become milky? Explain fully.

2. In the same way test alcohol. Is it an organic compound?

3. Mix 5 grams of sugar with 5 grams of powdered copper oxide. Place the mixture in a hard-glass test tube fitted with a delivery tube that dips into 10 cc. of limewater in another test tube. Heat the mixture. Note the drops of water on the cool upper portion of the test tube. Explain. Note the precipitate produced in the limewater. Explain. What is the reddish material in the test tube? Explain. The reactions that take place are as follows:

$$(1)\quad C_{12}H_{22}O_{11} + 24\ CuO \longrightarrow 11\ H_2O + 12\ CO_2 + 24\ Cu$$

$$(2)\quad CO_2 + Ca(OH)_2 \longrightarrow \underline{CaCO_3} + H_2O$$

The carbon dioxide test is the best test for carbon in a compound.

HYDROCARBONS

The hydrocarbons are organic compounds composed of hydrogen and carbon. Methane CH_4, ethane C_2H_6, and acetylene, C_2H_2, are the most common gaseous hydrocarbons. Gasoline, kerosene, benzene, and turpentine are liquid hydrocarbons. They contain a greater number of carbon and hydrogen atoms than do the gases. The solid hydrocarbons, like paraffine and vaseline, contain a still higher number of carbon atoms. The gases burn readily. Illuminating and fuel gases usually contain one or more of them. The liquids are volatile and inflammable. They are good solvents for fats and waxes.

Note: For further information concerning the hydrocarbons read almost any up-to-date elementary textbook on chemistry or a good organic chemistry such as Norris' "Organic Chemistry," or Stoddard's "Introduction to Organic Chemistry."

EXPERIMENT 32

Hydrocarbons

MATERIALS. Calcium carbide, gasoline, kerosene, lard or butter, paraffine candles, chloroform, benzene, carbon tetrachloride.

APPARATUS. Test tubes, test tube rack, evaporating dish, stirring rod.

A. Composition of Hydrocarbons.

1. Explain how you would prove the presence of hydrogen in a substance. (See Experiment 12, A.)

2. Explain how you would test for carbon a substance which does not char when heated. (See Experiment 31, B and C.)

B. Some Common Gaseous Hydrocarbons.

1. Light the gas from the Bunsen burner. Test for hydrogen by the method explained above, *i.e.* hold a cold object

above the flame and look for drops of water. Does illuminating gas contain hydrogen? Now explain why a cold flatiron or a teakettle filled with cold water becomes wet when first placed over a gas burner of the kitchen range. Make the flame colored by closing the hole in the burner. Apply the test for carbon given above, *i.e.* hold a cold object in the flame. Is "soot" deposited? Does illuminating gas contain carbon? Methane is the chief hydrocarbon in illuminating gas. What is its formula? Write the equation, indicating the products formed when methane burns.

2. Half fill a test tube with water and prepare to work rapidly. Stand it in the rack and drop into it a piece of calcium carbide about the size of a bean. Note the odor of the acetylene. Light the escaping gas. Describe the flame. How can the gas be used for lighting purposes? The formula for acetylene is C_2H_2. Write the equation for the formation of acetylene from calcium carbide and water. Write the equation, indicating the products formed when acetylene burns in the air depositing much soot. With the proper kind of burner acetylene may be used for illuminating purposes. Enough air is admitted to completely burn the acetylene and no soot is formed. Write an equation for the complete combustion of acetylene.

C. Some Common Liquid Hydrocarbons.

1. Pour 1 cc. of gasoline into an evaporating dish and the same volume of kerosene into another. (Two students may perform this test together.) Note the time it takes each to evaporate. Which is the more volatile?

2. Test the inflammability of each hydrocarbon by dipping the end of the stirring rod into the liquid and then

bringing it to the tip of the flame. Which substance is the most inflammable? Why should you be so careful in using gasoline near a flame?

3. Dissolve some fat, such as butter or lard, in kerosene and in gasoline. Which of these liquids is best to use in cleaning spots from clothing? Why?

4. What is the source of gasoline and kerosene?

5. Benzene has the formula C_6H_6. It is called an aromatic hydrocarbon. Note its odor; test its inflammability. What is the source of benzene? What are some of the important commercial products formed from benzene?

D. Solid Hydrocarbons.

1. Paraffine is a solid hydrocarbon. Obtain a paraffine candle, light it, and prove that it contains hydrogen and carbon.

2. What is the source of paraffine?

3. What is vaseline?

E. Chloroform and Carbon Tetrachloride.

Part or all of the hydrogen atoms in methane, CH_4, and in the other hydrocarbons may be replaced by different elements and radicals. If one hydrogen atom in methane is replaced by chlorine, *mono*-chlor-methane, CH_3Cl, is formed. If two are replaced, *di*-chlor-methane, CH_2Cl_2, is formed. If three are replaced, *tri*-chlor-methane, $CHCl_3$, is formed; this is chloroform. If four are replaced, *tetra*-chlor-methane, CCl_4, is formed; this is carbon tetrachloride.

1. Obtain 5 cc. of chloroform. Note its odor. Place a drop on your hand. Is it volatile?

2. Dip the stirring rod into it and hold it in the flame. Is it inflammable?

3. Try to dissolve a drop of olive oil in it. Result?

4. Chloroform is an anæsthetic and is a useful and safe cleansing agent, since it is non-inflammable.

5. Obtain 5 cc. of carbon tetrachloride. Note its odor. Place a drop on your hand. Is it volatile?

6. By means of the stirring rod test its inflammability. Result? Pour some on a burning splint. Result? It is sold as "Pyrene" for extinguishing fires.

7. Try to dissolve olive oil in it. Result? It is much used for cleansing purposes. It is the chief constituent of "Carbona."

ALCOHOLS

Alcohols are organic hydroxides. The hydrogen atoms in a hydrocarbon may be replaced by elements or radicals. If a hydrogen atom is replaced by a hydroxyl group, we have an alcohol. For example, the hydrocarbon methane has the formula CH_4. Replace one hydrogen atom by the hydroxyl group OH and we have CH_3OH, which is *methyl alcohol,* called *wood alcohol.* Similarly, the hydrocarbon ethane is C_2H_6. Remove one hydrogen atom and replace it by OH and we have C_2H_5OH, *ethyl alcohol,* called *common alcohol* or *grain alcohol.* These organic hydroxides, like the inorganic hydroxides, will combine with acids to form organic salts, called *esters.* In every other respect they are unlike inorganic hydroxides. Although the common alcohols are soluble in water, the solutions will not conduct an electric current or affect litmus or feel slippery. Methyl alcohol and ethyl alcohol are volatile, colorless liquids, having rather pleasant odors. They are good solvents, good disinfectants, and preservatives.

EXPERIMENT 33

Some Common Alcohols

MATERIALS. Ethyl alcohol, methyl (wood) alcohol, litmus paper, camphor gum, iodine, a solution of iodine in potassium iodide, sodium hydroxide, patent medicine, ether, olive oil, carbolic acid, glycerin.

APPARATUS. Stirring rod, evaporating dish, test tubes.

A. Properties of the Common Alcohols.

1. What is the chemical name for common alcohol? Write its formula. What is the chemical name for wood alcohol? Write its formula.

2. Obtain 10 cc. of each liquid in two clean, dry test tubes. Note the odor of each. Describe the difference.

3. Using a clean stirring rod, taste a drop of each. Describe the difference.

Caution: Do not swallow the liquids — they are poisons. Methyl alcohol (wood alcohol) produces blindness and death. Ethyl alcohol is a "habit" producing drug, and produces death ultimately from slow poisoning.

4. Test the solubility of each alcohol in water.

5. Test them with strips of red and with blue litmus. Do alcohols affect litmus?

6. Pour 2 cc. of each alcohol in different evaporating dishes. Apply the flame to each until it burns. Note the color of the flame and the heat given off by each. Do alcohols make good fuels? Which is the most often used for fuel? Why? Could they be used for illuminating purposes? Why? Write the equation to show the products formed when the alcohols burn.

7. To a test tube half filled with water add a piece of camphor gum the size of a bean. Does it dissolve? Pour off

the water and add 5 cc. of ethyl alcohol; shake. Does it dissolve? This forms the so-called "spirits of camphor." Add water to a crystal of iodine. Does it dissolve? Pour off the water and add 5 cc. of alcohol. Result? This is called "tincture of iodine." What are its uses? Is alcohol a good solvent? Why are flavoring "extracts" largely alcohol? Why is it used in patent medicines? Should methyl alcohol be used for these purposes? Why? Ethyl alcohol is used to disinfect wounds. Should methyl alcohol be used for this purpose? Why? Ethyl alcohol is used for "alcohol rubs." Should methyl alcohol be used as well? Why? Why is methyl alcohol used for preserving fruits and vegetables in specimen jars rather than ethyl alcohol?

8. Summarize the properties of the common alcohols.
9. Summarize the uses of each.
10. What is the commercial source of each?

B. Iodoform Test for Ethyl Alcohol (Grain Alcohol).

1. Alcohol can often be detected by its odor or its taste. A better test is the following: To 10 cc. of liquid add 5 cc. of a solution of iodine in potassium iodide. Now add a solution of sodium hydroxide *one* drop at a time, shaking the mixture well, till the iodine color vanishes. Warm gently, and let it stand for a few minutes. A yellow precipitate of iodoform with its characteristic odor will be formed. If only a small amount of alcohol is present, the crystals may not form but the odor will be recognized.

Try this test upon a solution of 2 cc. of alcohol in 10 cc. of water.

Test a patent medicine for alcohol.

C. Ordinary Ether $(C_2H_5)_2O$.

Ether is formed by the action of concentrated sulfuric acid upon ethyl alcohol. It is called, for this reason, "sulfuric ether" or "ethyl ether."

1. Obtain 5 cc. of ether. Note its odor. Place a drop on your hand. Is it volatile?

2. Dip the stirring rod into it and hold it in the flame? Is ether inflammable?

3. Dissolve a drop of olive oil in the ether. Is it a good solvent? Why then is it not more often used for cleaning purposes?

4. What is the important use of ether?

D. Phenol or Carbolic Acid, C_6H_5OH.

1. Pure phenol is a white crystalline substance. Examine a bottle of it, but do not remove any from the bottle.

It is soluble in water. The solution is usually pink due to slight decomposition, and is called carbolic acid.

2. Obtain 1 cc. of carbolic acid in a test tube. Describe its odor. Test it with red and with blue litmus. Is it a true alcohol? Do not get any on the hands; it causes serious burns. Alcohol is the antidote. What is carbolic acid used for?

E. Glycerin, $C_3H_5(OH)_3$.

1. Obtain 5 cc. of glycerin in a test tube. Has it an odor? Taste it. Result? Pour about 1 cc. into another test tube half full of water. Shake. Is it soluble?

2. Test the solution with litmus. Is it a true alcohol?

3. What is nitroglycerin? What is dynamite? What are they used for?

What important uses has glycerin in the home?

ORGANIC ACIDS

An organic acid is composed of carbon, hydrogen, and oxygen. They all contain one or more carboxyl groups, COOH. They are nearly all crystalline solids. Some acids, such as acetic, tartaric, citric, and oxalic, have a sour taste and affect litmus as inorganic acids do. Others such as stearic, palmitic, benzoic, tannic, and salicylic acids are almost tasteless. As has been noted, these acids react with the alcohols (the organic bases) to form esters (organic salts). These esters are the basis of many of our artificial flavoring extracts and perfumes.

EXPERIMENT 34

Properties and Uses of Some Common Organic Acids

MATERIALS. Acetic acid, alcohol, amyl alcohol, concentrated sulfuric acid, vinegar, tartaric acid, sodium bicarbonate, cream of tartar, citric acid, oxalic acid, potassium permanganate solution, tannic acid, ferrous sulfate.

APPARATUS. Test tubes.

A. Acetic Acid, $H(C_2H_3O_2)$ or CH_3COOH.

1. Note the odor of a dilute solution of acetic acid. Very carefully taste it. Test it with litmus paper. Result?

2. To 3 cc. of acetic acid add 3 cc. of ordinary alcohol, then, carefully, 3 cc. of concentrated sulfuric acid. Warm and note the sweet odor of *ethyl acetate*. This is a test for acetic acid. Write the equation and name each substance.

$$C_2H_5OH + CH_3COOH \longrightarrow CH_3COOC_2H_5 + H_2O$$

Ethyl acetate is an organic salt formed from an organic acid and an alcohol. These salts are called esters. They have sweet odors and are often used for artificial flavorings.

To 3 cc. of acetic acid add 3 cc. of amyl alcohol and then 3 cc. of concentrated sulfuric acid. Warm gently and note the odor of the ester amyl acetate. For what artificial flavoring is it used?

3. Obtain 3 cc. of vinegar. Smell it, taste it, and test it with litmus paper. What acid do you think is present? To prove your answer add alcohol and sulfuric acid as in (2) and obtain the ester test. What acid is in vinegar? For what purposes is vinegar used in cooking?

B. Tartaric Acid, $H_2(C_4H_4O_6)$ or $C_2H_4O_2(COOH)_2$.

1. Obtain a crystal of tartaric acid. Describe its taste. Pulverize the crystal and dissolve a small portion in water. Test the solution with litmus. Has tartaric acid the characteristic property of an acid?

Mix the rest of the powdered crystal with an equal amount of dry sodium bicarbonate. Is there any action? Now add water. What is given off? Write the equation and name each substance.

$$NaHCO_3 + H_2C_4H_4O_6H \longrightarrow HNaC_4H_4O_6 + H_2O + CO_2$$

Tartaric acid is used in baking powders. Why? (See Experiment 29 on Carbonates.)

2. Cream of tartar is a salt of tartaric acid $HKC_4H_4O_6$ (hydrogen potassium tartrate). Taste it. Dissolve a small amount in water and test with litmus. Result? Mix a small amount with sodium bicarbonate. Is there any action? Now add water. Result? Write the equation and name each substance.

$$HKC_4H_4O_6 + NaHCO_3 \longrightarrow NaKC_4H_4O_6 + H_2O + CO_2$$

3. What is the source of cream of tartar and tartaric acid?

4. What are the little hard "lumps" often found in canned grapes that have been kept for some time?

C. Citric Acid, $H_3(C_6H_5O_7)$ or $C_3H_5O(COOH)_3$.

1. Obtain a crystal of citric acid. Describe its taste. Dissolve it in water and describe its action on litmus. In what fruits is this acid chiefly found? What is its commercial source?

2. How may it be used in making artificial lemonade?

D. Oxalic Acid, $H_2C_2O_4$ or $(COOH)_2$.

1. Obtain a few crystals of oxalic acid.

Caution: Do not taste them.

Oxalic acid is a poison. In what plants is oxalic acid found?

2. Describe the appearance of the crystals.

3. Place the crystals in half a test tube of cold water. Shake the tube. Result?

4. Now heat the water in the tube. Is oxalic acid more soluble in hot or cold water? Test the solution with litmus paper. Result?

5. Make a stain upon your hand with a solution of potassium permanganate and remove it by applying some of the solution of oxalic acid that you have just prepared. *Wash the hand thoroughly.* A solution of oxalic acid is often used in preparations for removing stains from the hands and nails.

6. Place a teaspoonful of bleaching powder in 25 cc. of water. Stir well at two-minute intervals for ten minutes, then filter. Call the filtrate, Solution No I. Dissolve 5 grams of oxalic acid in 50 cc. of water. Call this Solution No. II. This is the common ink eradicator. Try it.

E. Tannic Acid (sometimes called Tannin).

1. Obtain 1 gram of tannic acid. Describe its appearance. What is its commercial source?

2. Put it into half a test tube of cold water. Does it dissolve? Heat the tube. Does it dissolve in hot water? Test the solution with litmus. Result? *Cautiously* taste the solution. Describe the taste.

3. To half of the tannic acid solution add a few drops of ferric chloride, $FeCl_3$. Result? This is an ink.

4. To the other half of the solution add a few drops of ferrous sulfate, $FeSO_4$. Notice that the black precipitate (the ink) is not formed at once, but forms slowly as the ferrous salt is oxidized by the air to the ferric salt. Tannic acid and ferrous sulfate are used in the manufacture of inks. These inks write blue at first because a blue dye is added. The ink turns black on standing because the ferrous salt is oxidized to the ferric salt by the oxygen of the air, and ferric tannate is a deep blue-black.

5. Many plants contain tannic acid. It is in oak bark, sumach leaves, and the leaves of other trees, in tea leaves, in coffee berries, in rose leaves, and rose petals.

In making rose beads the crushed wet rose petals are allowed to stand in a rusty iron pan, or powdered "copperas" (ferrous sulfate) is added. The mass becomes very black. Explain.

6. Tannic acid makes skins tough and "leathery." It is, therefore, used in "tanning" hides in the manufacture of shoes and gloves.

What is one objection to the constant drinking of beverages containing much tannic acid like strong green tea or strong coffee?

F. A Note on Esters.

In A, 2 of this experiment the esters, ethyl acetate and amyl acetate, were prepared. Ethyl acetate is called artificial oil of apple. Amyl acetate is artificial banana oil. Artificial oil of wintergreen is methyl salicylate, the ester (organic salt) prepared from methyl alcohol (organic base) and salicylic acid (organic acid). Nearly all the oil of wintergreen on the market is the artificial product.

Most esters are more or less fragrant volatile oils. They are usually insoluble in water but soluble in alcohol, and this alcoholic solution is called an "extract." These extracts form the basis of many of our flavoring extracts and perfumes.

Fats are solid esters also insoluble in water but without odor.

If the alcohol glycerin, $C_3H_5(OH)_3$, combines with stearic acid, $C_{17}H_{35}COOH$, an ester glyceral stearate, $(C_{17}H_{35}COO)_3C_3H_5$, is formed. This is a fat called stearin. An ordinary fat such as beef tallow is made up largely of this fat and glyceral palmitate, $(C_{15}H_{31}COO)_3C_3H_5$, and glyceral oleate, $(C_{17}H_{33}COO)_3C_3H_5$.

EXPERIMENT 35

(Class Experiment)

Fuels and Illuminants

MATERIALS. Sawdust, coal, ice.

APPARATUS. Test tubes, large glass test tube, side-necked test tube, delivery tube, clay pipe stem.

A. Solid Fuels.

1. *Wood:* What woods are the most commonly used for heating purposes in this region? Which is best? Why?

What are the chief elements in wood? What are the products formed when wood is burned in the air?

If wood is heated without air entirely different products are formed. Half fill a hard-glass test tube with small pieces of hard wood or sawdust. Clamp the test tube in a horizontal position on the ring stand. By means of a right-angled delivery tube attach the hard-glass test tube to a side-necked test tube by means of two well-fitted one-holed stoppers. Attach a jet to the side-necked test tube. Keep the side-necked test tube cool by standing it in a beaker of ice water. Heat the wood till no further change takes place. Test the gas that escapes from the side-necked test tube. Will it burn?

When the hard-glass tube is cold examine the contents. Remove the black residue. What is it?

Note the odor of the liquid in the side-necked test tube. Test with litmus. Result? Is water formed when wood is decomposed? Is an acid formed? What acid chiefly? What compounds are made commercially by heating hard wood in the absence of air?

When a substance is heated in the absence of air, the process is called *destructive distillation.*

2. *Coal:* What is the source of coal? Of what is it chiefly composed? What are the products formed when it is completely burned in air?

Half fill a hard-glass test tube with small pieces of soft coal. Clamp the test tube in a horizontal position on the ring stand. Set up the apparatus as in A. Heat the coal till no further change takes place. What is the gas that is formed? What remains in the hard-glass tube? What is the gas that is formed? What collects in the side-necked test

tube? Test for an acid. Result? Test for a sulfide. What commercial products may be obtained by the destructive distillation of coal?

B. Liquid Fuels and Illuminants.

1. *Alcohol:* Why is grain or ethyl alcohol not more commonly used for fuel? What is the color of the alcohol flame? Could it be used for illuminating purposes?

2. *Crude Petroleum:* This fuel is used in many furnaces where intense even heat is needed. Visit the furnace room at your school or the large range in the lunch house and note the intense heat produced by the burning jet of crude oil. Describe the burner.

3. *Gasoline:* What is the source of gasoline? Can it be used for fuel? How? Can it be used for lighting purposes? How?

4. *Kerosene:* What is the source of kerosene? How can it be made to burn with a blue flame?

C. Gaseous Fuels and Illuminants.

Some of the gases used for fuels and illuminants are *natural gas, coal gas,* and *acetylene.* What is natural gas?

Explain how the same gas can be used either for lighting purposes or for fuel. What is a Welsbach mantle? Explain its use.

X. CHEMISTRY OF FOODS

In studying the chemistry of foods, the Food Chemistry outline in the Appendix of this manual will be found useful. The following are good reference books:

Bulletin No. 28, U. S. Department of Agriculture, Appendix A.
Bulletin No. 13, American School of Home Economics.

Weed, Chemistry in the Home.
Wellman, Food Study.
Sherman, Food Products.
Snell, Elementary Household Chemistry.
Leach, Food Inspection and Analysis.
Brownlee, Fuller, and others, Chemistry of Common Things.

INORGANIC CONSTITUENTS OF FOODS

EXPERIMENT 36

Water in Foods

MATERIALS. White bread, milk, meat, potato.
APPARATUS. Laboratory balances, drying oven, evaporating dish.

A. The Presence of Water in Foods.

How is the presence of water in food determined? (See Experiment 12 C.) Test four foods for water.

B. The Amount of Water in Foods.

1. To determine exactly how much water a substance contains it is weighed, then dried and weighed again. The loss in weight is the weight of the water that was in the substance. Divide the weight of the water by the weight of the substance before drying and multiply the result by 100 to give the per cent of water in the substance.

Find the per cent of water in bread as follows: Label your evaporating dish with your name and weigh it. Obtain the largest cube of bread that will go into the dish and weigh both as carefully as you can on the laboratory balance. Place the dish and the bread in the drying oven for about six hours, keeping the temperature below 106° C. Why? When completely dry cool and weigh. Tabulate the results as follows:

(*a*)	Weight of empty dish	=—— g.
(*b*)	Weight of dish and bread before drying	=—— g.
(*c*)	Weight of dish and bread after drying	=—— g.
(*d*)	Weight of bread (*b*) − (*a*)	=—— g.
(*e*)	Weight of water in bread (*b*) − (*c*)	=—— g.
(*f*)	Per cent of water in bread (*e*) ÷ (*d*) × 100	=—— %

2. From the table in the Appendix make a list of five foods which contain much water (80 %–100 %), five which contain a medium amount of water (15 %–80 %), and five containing very little water (less than 15 %).

3. What tissues of the body contain much water? What tissues contain the least water?

4. Of what use is water to the body?

INORGANIC SALTS IN FOODS AND BONES

EXPERIMENT 37

Inorganic Salts in Foods (Mineral Matter or Ash)

MATERIALS. Bones that have soaked for at least two days in hydrochloric acid, ammonium hydroxide, milk, meat, potato, bread.

APPARATUS. Porcelain crucibles, clay triangle, evaporating dish.

A. Inorganic Salts in Foods.

Inorganic salts do not burn; they remain as ash, when the organic matter of the food has been burned away.

1. To show the presence of inorganic salts in a food place about 1 gram of the food in a porcelain crucible and heat with the crucible inclined. In this way, heat milk, meat, potato, and bread.

(Four students may work together, the first heating milk,

the second meat, etc. Each student should make observations and reports on four foods.)

2. From the table in the Appendix make a list of foods containing much mineral matter and a list of foods containing little or no mineral matter.

B. To Show the Presence of Inorganic Salts in Bones.

1. Clean a small bone by boiling in water. Place the clean bone in a beaker of hydrochloric acid and allow it to stand for two days. Explain the change that has taken place in the bone. Keep the bone.

2. Place 10 cc. of the clear liquid in an evaporating dish and evaporate to dryness. What is the dry residue that remains?

3. Prove the presence of calcium salts in the ash by dissolving it in 5 cc. of hydrochloric acid. Filter. Make the solution alkaline with ammonium hydroxide. What is the white precipitate chiefly?

4. What tissues of the body contain much mineral matter and what tissues very little?

CARBOHYDRATES

Carbohydrates are organic compounds which form the most important part of our foods. They contain no nitrogen (non-nitrogenous). They are composed of carbon, hydrogen, and oxygen, the hydrogen and oxygen usually being present in the proportion in which it is found in water, that is, twice as many atoms of hydrogen as oxygen. The starches and the sugars are the most important carbohydrates found in foods.

The Starch Group $(C_6H_{10}O_5)_n$

EXPERIMENT 38

Starch and Dextrin

Materials. Corn starch, rice starch, wheat starch, potato starch, dextrin, concentrated sulfuric acid, Fehling's solution, dilute sulfuric acid, sodium carbonate, litmus paper, iodine solution, potato, meat, milk, apple, banana, nuts, rolled oats, raisins.

Apparatus. Test tubes, microscope, labels, asbestos mat.

A. Properties of Starch.

1. Obtain about one gram of corn starch, rice starch, wheat starch, and potato starch in separate tubes. Is there any difference in the appearance of each?

2. Mount a few grains of each on microscope slides and draw the appearance of each under the high power.

3. Add 10 cc. of water to each tube. Shake the mixture well and then let it stand for one minute. Does starch dissolve in cold water?

4. Shake the mixture of corn starch and water again and then boil it for a few minutes. (Keep this for 9.)

5. Gently heat a little corn starch in a dry test tube until it becomes brown. What is formed? Taste it. Try the solubility of some pure dextrin in water. What is dextrin used for? Why is the brown crust of bread sweet?

6. Heat strongly one gram of starch in a dry test tube. What collects on the sides of the tube? Explain. What remains in the tube? What does this show about the composition of starch? Write an equation to show what took place.

7. Add a few drops of concentrated sulfuric acid to some dry starch in a test tube. Warm gently. Explain results. How does this also show the composition of starch?

8. Burn a small lump of starch on your asbestos mat. What products are found? Write an equation to illustrate.

9. To 5 cc. of starch paste prepared in (4) add 5 cc. of Fehling's solution and boil. Result? (To prepare Fehling's solution, see Appendix.)

10. To 10 cc. of starch paste add 10 cc. of dilute sulfuric acid. Boil for five minutes. Add solid sodium carbonate till the mixture is alkaline to litmus, then add Fehling's solution and boil. Result?

Note: If a red precipitate is not obtained, try again. The starch combines with a molecule of water to form glucose (grape sugar). Glucose is a *reducing* sugar and reduces the copper sulfate in the Fehling's solution to cuprous oxide. Cuprous oxide is the red precipitate. When a substance like starch takes up water and becomes a new substance, it is said to *hydrolyze*. The process is called *hydrolysis*. There are several ways of hydrolyzing substances: (1) By boiling with a dilute acid, (2) boiling with a base, (3) by means of an enzyme or ferment.

How is starch caused to hydrolyze? Could any acid be used other than sulfuric acid? Write this equation for the hydrolysis of starch and name each substance:

$$C_6H_{10}O_5 + H_2O \text{ (by means of } H_2SO_4) \longrightarrow C_6H_{12}O_6.$$

B. The Iodine Test for Starch.

1. Obtain about 10 cc. of a solution of iodine in one of your clean test tubes. To some dry starch add about 1 cc. of iodine solution. Results?

2. To a test tube half full of water add two drops of cold starch paste. Shake well, then add about two drops of the iodine solution. Results? Boil till the color disappears, then cool again and the color will return if you have not boiled it too long. This is called the iodine test for starch.

3. To detect the presence of starch in foods the food should (1) be broken into small pieces or powdered. Why? (2)

It should be boiled two or three minutes in water. Why? (3) It should be cooled. Why? (4) Two drops of iodine solution should be added.

4. Test the following foods for starch according to the method above and record the results in a table: potato, meat, milk, apple, banana, nuts, rolled oats, raisins.

Of what use to the body is starch?

Much Starch	Little Starch	No Starch

CELLULOSE

Cellulose forms the walls of the cells of plants. It is most abundant in the roots and stems, less in the leaves, and least in the fruit. "Seed hairs" are almost pure cellulose. Since cotton fibers are seed hairs, cotton is almost pure cellulose. The fiber in young tree trunks is used for paper. Cellulose is not digestible, but it forms an important part of food, for it gives it the needed bulk.

EXPERIMENT 39

Cellulose

Materials. Carrots, beets, celery, potato, cabbage, lettuce, apples, grapes, dilute hydrochloric acid, dilute sodium hydroxide, solid sodium carbonate, zinc chloride, Schweitzer's reagent (see Appendix), concentrated nitric acid, alcohol, ether.

Apparatus. Test tubes, beaker.

A. Occurrence of Cellulose, $(C_6H_{10}O_5)_n$.

1. Examine carefully roots (carrot, beet), stems (celery, potato), leaves (cabbage, lettuce), and fruits (apples, grapes). Draw the position of the chief cellulose fibers in each.

2. Name five vegetables or fruits with much cellulose and five with little or no cellulose.

B. Properties of Cellulose.

1. Test the solubility of cellulose (a small amount of cotton in each case) in water, dilute hydrochloric acid, dilute sulfuric acid, and dilute sodium hydroxide. What is the result in each case? Is the cellulose digestible? Of what value is it in the foods?

2. Test cellulose (cotton) with a solution of iodine. Result?

3. Test cellulose (cotton) with Fehling's solution. Result after boiling?

4. Cover a little cotton in a test tube with concentrated sulfuric acid. Allow it to stand two minutes. Neutralize the acid with sodium carbonate (till effervescence ceases and it turns red litmus blue). Now add Fehling's solution and boil. Explain and write equations. What possible use does this suggest for old papers and rags?

5. (Instructor): Test the solubility of cellulose in a solution of zinc chloride in concentrated hydrochloric acid.

6. (Instructor): Prepare a fresh solution of cuprous ammonia or Schweitzer's reagent according to the method given in the Appendix. Show the solubility of cellulose in this solution. Reprecipitate the cellulose by adding hydrochloric acid. This is a test for cellulose.

7. (Instructor): Prepare "nitro-cellulose" or "guncot-

ton" and "collodion" by mixing 20 cc. of concentrated sulfuric acid and 10 cc. of concentrated nitric acid. Cool this to room temperature. Immerse absorbent cotton or clean cotton gauze in this mixture for about one minute. Wash well with cold water, wring it out, and hang it up to dry. This is "guncotton."

Burn a piece of guncotton and compare with the burning of untreated cotton.

Shake a portion of the dry guncotton in a mixture of equal parts of alcohol and ether. The clear solution is "collodion." Place a little in a glass plate and allow it to stand. Result? What is collodion used for? What is "New Skin"? What is celluloid?

8. Is cellulose digested? Is it of use in foods? Explain.

GUMS AND PECTIN

Gums are compounds closely related to the carbohydrates, having very complex constitutions. They are generally soluble in water but not in alcohol. The water solutions when cold form jellies, or sticky mucilage-like solutions.

Pectin is a carbohydrate found in fruits, which causes the juices to "jelly" when boiled with sugar. Pectin will produce a jelly only in the presence of at least half of one per cent of acid. Sugar also helps to precipitate the pectin and to form the jelly.

EXPERIMENT 40

Gums and Pectin

MATERIALS. Gum arabic or gum tragacanth, agar-agar or Iceland moss, iodine solution, Fehling's solution, concentrated sulfuric acid, solid sodium carbonate, alcohol, cranberries.

APPARATUS. Test tubes, beaker.

A. Gums.

1. Note carefully the physical properties of gum arabic and agar-agar with special reference to color, odor, taste, and form.

2. Dissolve about one gram of gum arabic in a half test tube of boiling water. Boil one minute. Cool the solution. What is formed? Repeat, using agar-agar. What is formed?

3. To about 1 cc. of the cool gum arabic solution add a few drops of iodine solution. Result? Repeat, using agar-agar. Result?

4. To about 1 cc. of the gum arabic solution add Fehling's solution and boil. Result? Repeat, using agar-agar. Result?

5. To the remainder of the gum arabic solution add (cautiously) 5 cc. of concentrated sulfuric acid and boil two minutes. Add solid sodium carbonate till the acid is neutralized, then add Fehling's solution and boil. Explain.

6. Try to dissolve one gram of gum arabic in alcohol. Result? Repeat, using agar-agar. Are gums soluble in alcohol?

7. How are some of the gums used in the preparation of foods?

8. Give some of the commercial uses of gums. Why is it used by bacteriologists for culture media?

B. Pectin.

1. Slice five cranberries in your beaker, add 50 cc. of water, and boil ten or twenty minutes. Filter while hot.

2. To 15 cc. of the clear filtrate add 15 cc. of alcohol. Result? (A jelly-like precipitate of pectin should be formed. This is a test for pectin in fruits.)

3. To 15 cc. of the clear filtrate add 10 grams of sugar and boil for ten minutes. Cool. A jelly indicates the presence of pectin.

Do cranberries contain pectin?

4. To the remainder of the filtrate add 5 cc. of concentrated sulfuric acid. Boil for five minutes. Neutralize the acid with solid sodium carbonate. Then add Fehling's solution and boil. Result? (Like starch, pectin is hydrolyzed to reducing sugars by long boiling with a dilute acid, or by boiling for a short time with a strong acid.)

5. Summarize the necessary precautions to be observed in making jelly.

6. What fruits contain much pectin? Which contain very little?

7. Repeat B, 1 and B, 2, using an apple and one other fruit. Report the presence or absence of pectin.

Test also a beet for pectin. Could jelly be made from a beet?

SUGARS

The sugars are carbohydrates widely distributed in nature. They form crystals and dissolve in water. They have a sweet taste. There are two groups of sugars: (1) The *monosaccharides* or monoses, including *glucose, fructose,* and *gelactose* having the general formula $C_6H_{12}O_6$, and (2) the *disaccharides* or dioses, including *sucrose, lactose,* and *maltose* having the general formula $C_{12}H_{22}O_{11}$.

Glucose called grape sugar or dextrose is found in grapes. Fructose called fruit sugar or levulose is formed with glucose when sucrose is hydrolyzed. Gelactose is formed with glucose when lactose is hydrolyzed.

EXPERIMENT 41

Sugars

MATERIALS. Sucrose (cane sugar), lactose (milk sugar), dextrose (grape sugar), in five-gram portions, concentrated sulfuric acid, iodine solution, Fehling's solution, dilute sulfuric acid, solid sodium carbonate, raisins, honey, rice, beets, lemons, flour.

APPARATUS. Test tubes, small beaker.

A. Physical Properties of Sugars.

1. Obtain 5 grams of sucrose or cane sugar, $C_{12}H_{22}O_{11}$. Note its form and taste. Place about 1 gram in a test tube half full of cold water. Result?

2. Obtain 5 grams of lactose, milk sugar, $C_{12}H_{22}O_{11}$, and note its form and taste. Place about 1 gram in a test tube half full of cold water. Heat the water. Is it more soluble in hot or in cold water? Is it as sweet as cane sugar? Is it as soluble as cane sugar?

3. Repeat (2), using grape sugar, $C_6H_{12}O_6$, sometimes called glucose or dextrose. Is it as sweet as cane sugar? Is it as soluble? Will it crystallize as easily?

B. Chemical Properties of Sugars.

1. Place about one gram of sucrose in a dry test tube and heat until it melts. This is called barley sugar and when cool it forms a pale yellow glassy mass.

Heat more strongly. Note the change in color, odor, and taste. What is the brown sirup formed?

Now heat the tube intensely until the substance decomposes. What collects on the cool sides of the test tube? What remains in the tube? What does this prove concerning the composition of cane sugar (sucrose)? Is it true

carbohydrate? What is its formula? Write the equation to show its complete decomposition.

2. In like manner heat 1 gram of lactose until it is completely decomposed. Result? Is it also a true carbohydrate? What is its formula? Write the equation to show its complete decomposition.

3. Repeat (2), using grape sugar. Is it a true carbohydrate? What is its formula? Write the equation to show its complete decomposition.

4. Place 1 gram of each sugar in three different test tubes and cover with concentrated sulfuric acid. Warm if necessary. Note the results in each case and explain fully. Write an equation in each case to show the decomposition of the sugars by acid. This is a second method to prove sugars to be carbohydrates.

5. Dissolve one gram of each sugar in hot water in separate test tubes, cool, and add a few drops of iodine solution to each. Do sugars affect iodine solution?

6. Dissolve 1 gram of grape sugar in hot water, add 5 cc. of Fehling's solution, and boil. A red or yellow precipitate of cuprous oxide, Cu_2O, is formed. Grape sugar *reduces* the copper sulfate in the Fehling's solution to cuprous oxide which forms the red precipitate. Such a sugar is called a *reducing* sugar.

7. Dissolve 1 gram of sucrose, cane sugar, in water, add Fehling's solution, and boil. Is sucrose a reducing sugar?

8. Repeat (7), using lactose. Is lactose a reducing sugar?

9. Place 5 grams of sucrose in your small beaker. Dissolve in 25 cc. of water. Add 10 cc. of dilute sulfuric acid and boil 1 minute. Now add solid sodium carbonate until the

solution is alkaline to litmus, then add Fehling's solution and boil. Is a reducing sugar present?

The sugar is *hydrolyzed* as was starch in Experiment 38. In this case two reducing sugars are formed, dextrose and levulose. Both have the formula $C_6H_{12}O_6$. Write the equation for the hydrolysis of sucrose, naming each substance.

$$C_{12}H_{22}O_{11}+H_2O \text{ (by means of } H_2SO_4) \longrightarrow C_6H_{12}O_6+C_6H_{12}O_6$$

Now explain why lemon juice or vinegar is used in making taffy or in general to prevent the graining of cane sugar sirup.

10. Glucose is a fermentable sugar, alcohol and carbon dioxide being formed.

$$C_6H_{12}O_6+\text{yeast} \longrightarrow 2\ C_2H_5OH+2\ CO_2$$

Lactose and cane sugar are not fermentable by pure yeast. An enzyme contained in the yeast hydrolyzes these sugars, forming some glucose. Then the glucose formed ferments.

11. Summarize the results of the tests on the three sugars in a table under the following heads: Taste as compared with cane sugar. Solubility in water. Action of intense heat. Result of boiling with dilute acids. Action of Fehling's solution. Action of pure yeast.

C. Method of Testing Foods for Reducing Sugars.

1. Boil the substance in water after breaking it into small pieces, add Fehling's solution and boil again. A red precipitate of cuprous oxide indicates the presence of a reducing sugar.

2. Test the following foods for a reducing sugar. Name the sugar present if possible. (*a*) Raisins, (*b*) Honey, (*c*) Rice, (*d*) Meat, (*e*) Beet, (*f*) Lemon, (*g*) Flour.

3. Of what use are the sugars to the body?

FATS AND OILS

A fat is an ester. An ester is the organic salt formed when an alcohol (organic base) combines with an organic acid. When the alcohol glycerin, $C_3H_5(OH)_3$, combines with stearic acid, $C_{17}H_{35}COOH$, the fat glyceryl stearate (stearin), $(C_{17}H_{35}COO)_3C_3H_5$, is formed.

If glycerin combines with palmitic acid, $C_{15}H_{31}COOH$, the fat glyceryl palmitate, $(C_{15}H_{31}COO)_3C_3H_5$ (palmitin), is formed.

If glycerin combines with oleic acid, $C_{17}H_{33}COOH$, the fat glyceryl oleate, $(C_{17}H_{33}COO)_3C_3H_5$ (olein), is formed.

Ordinary fats are mixtures of these three fats. In solid fats, stearin and palmitin predominate. In oils olein predominates.

Fats are non-nitrogenous, organic compounds. They are composed of carbon, hydrogen, and oxygen, but they are by no means carbohydrates.

EXPERIMENT 42

Fats and Oils

MATERIALS. Lard, olive oil, butter, cottonseed oil, gasoline, ether, chloroform, carbon tetrachloride, solution of egg albumen in water, iodine solution, Fehling's solution, sodium hydroxide 4 *N*, Sudan III, castor beans, boiled egg yolk, walnuts, chocolate, grated cheese.

APPARATUS. Test tubes, evaporating dish, beakers.

Note: Do not throw fats or oils into the sink, put them in the jars

A. Physical Properties of Fats and Oils.

1. Obtain about 5 grams of each of the following: lard, olive oil, cottonseed oil. What is the source of each?

2. Note the color, odor, and taste of each. Are they soluble in water? To the tubes add respectively 50 cc. of gasoline, ether, chloroform, and carbon tetrachloride.

Caution: Have no flames near.

Shake well and then look for the oil. Result? Now explain how a grease spot on clothing may be removed by one of these solvents. Which is the best to use? Why? In removing a grease spot why apply solvent at the outside and work toward the center of the spot?

3. Place 1 cc. of olive oil in a test tube. Add 5 cc. of a solution of egg albumen in water. Shake vigorously for a minute. Result? This is called an emulsion. Let it stand and note that in time the oil will come to the top. The more perfect the emulsion the longer it will take for the oil to separate out. Milk is an example of a natural emulsion. Mayonnaise dressing is an example of a prepared emulsion. The disagreeable taste of castor oil is masked by preparing an emulsion by first adding orange juice, then baking soda, and stirring rapidly.

B. Chemical Properties of Fats and Oils.

1. In a test tube place a lump of lard about the size of a bean. Add 5 cc. of a solution of iodine. Result?

2. In another test tube place the same amount of lard and add 5 cc. of Fehling's solution and boil. Result?

3. In a clean evaporating dish place 2 grams of lard; warm gently. Result? Heat the lard more and more strongly and note results. The strong, irritating odor from hot lard or other fats or oils is due to the formation of *acrolein.*

4. To three drops of cottonseed oil add $\frac{1}{4}$ test tube of sodium hydroxide and boil for a minute or until the oil can

no longer be seen. A soap is formed. The process is called *saponification.* Write two equations to show the reactions that took place. Name all substances.

C. Tests for Fats and Oils.

1. The reagent Sudan III stains fats and oils. Cut open a castor bean or a sunflower seed; apply a drop of the reagent. Result? In like manner test boiled egg yolk for fat.

2. Some substances contain sufficient fat to give the "grease spot" test. Rub a piece of walnut on a page of your scratch pad placed on the table. Is a grease spot formed? Warm the spot over the burner. It should not disappear. In this way test chocolate.

3. The fat may be extracted from the substance by mixing well with ether or gasoline. The gasoline will dissolve the fat and then if allowed to evaporate, the fat will be left.

Put about 10 grams of grated cheese in one of your beakers. Add 25 cc. of gasoline; stir well.

Caution: Have no flames near.

Filter into your beaker and allow the filtrate to evaporate. What remains in the beaker?

4. What is the use of fats to the body? From the Appendix make a list of 10 foods containing much fat (80% to 100%). Make a list of 10 foods containing very little or no fat (10% to none). Name five fats or oils of commercial value and give their uses.

NITROGENOUS SUBSTANCES

Nitrogenous substances are very complex compounds, found in some plant and nearly all animal tissues. The most important nitrogenous substances are called *proteins.* They are composed of carbon, hydrogen, oxygen, and about

14% of nitrogen with varying amounts of sulfur and phosphorus. The proteins may be classified into four groups: (1) Those soluble in cold water and coagulated by hot water, called the *albumens* (egg albumen, blood albumen, milk albumen). (2) Those soluble in hot or cold water (casein in milk). (3) Those not soluble in hot or cold water, called *globulins* (myosin in meat, gluten in flour, and legumen in peas and beans). (4) Those soluble in hot water but not in cold, called *albuminoids* or *gelatinoids* because when the hot solution is allowed to cool a jelly is formed (collagen from skin, cartilage, and bones, and keratin from hair, horns, and hoofs).

EXPERIMENT 43

The Albumens and Casein

MATERIALS. Fresh egg albumen, concentrated nitric acid, ammonia, Millon's reagent, dry blood albumen, dry egg albumen, soda lime, red litmus paper, fresh milk, rennin, dilute hydrochloric acid or acetic acid.

APPARATUS. Test tubes, funnel, filter paper, evaporating dish, stirring rod.

A. The Albumens (Soluble in Cold Water, Coagulated by Hot Water).

1. Obtain 1 cc. of fresh egg albumen in a test tube. Note its physical properties. Add 20 cc. of cold water and shake well. Does it dissolve?

2. Heat the solution of egg albumen. Result?

3. Filter the coagulated albumen and place a portion of it in your evaporating dish. Heat slowly and note the peculiar odor of burning protein. Explain. This is the "burning test" for proteins.

4. To another portion of the coagulated albumen add

concentrated nitric acid till the albumen is covered. Warm gently. Result? Now pour off the acid, rinse with water, and add ammonia. Result? This is the xanthoproteic test for proteins.

5. Obtain about 10 cc. of blood albumen in water. Add 1 cc. of Millon's reagent and boil. Result? This is Millon's test for proteins.

6. Obtain 2 grams of dry blood or egg albumen, mix with soda lime, and heat in a test tube. Note the odor and hold a piece of moist red litmus at the mouth of the tube. What is the gas given off? Explain. This is the decomposition test for proteins.

7. Obtain 20 cc. of fresh milk in your evaporating dish and heat. What are the scums formed? By means of the stirring rod place some of the scum in a test tube and apply the xanthoproteic test (see 4 above). Result?

B. Casein (Soluble in Hot and Cold Water).

1. Is casein soluble in hot water? How do you know?

2. To a portion of the milk used in A, 7 add dilute hydrochloric acid or acetic acid. Result?

To another portion add rennin and warm gently. Allow it to cool for five minutes. Result?

3. To a part of the casein apply the burning test. Result?

4. Apply the xanthoproteic test. Result?

5. Apply the Millon's test. Result?

6. Apply the decomposition test, using soda lime. Result?

Questions

1. If albumen and casein were in a solution together, how could you separate one from the other?

2. What are some of the tests for albumen and casein?

EXPERIMENT 44

The Globulins and Albuminoids

Note to instructor: Have part 1 of A done at home. The gluten loaves should be submitted for approval and credit.

Materials. Flour, nitric acid, ammonia, Millon's reagent, soaked beans, bones soaked in hydrochloric acid for a week, soup bones, hair or feathers, sodium hydroxide 4 *N*, sodium plumbite solution.

Note: Sodium plumbite solution may be prepared by adding sodium hydroxide to lead acetate solution until the precipitate first formed dissolves on heating.

Apparatus. Muslin bag, test tubes, evaporating dish.

A. The Globulins (Insoluble in Hot or Cold Water).

Gluten is the globulin found in wheat and other cereals.

1. Into a cup full of flour stir just enough water to make a heavy dough. Place the dough in a muslin bag and knead it in the hand in a running stream of water till the water runs through clear. What part of the flour is removed in this manner? Examine the gluten remaining in the bag. What are its physical properties? Is it soluble in cold water? Leave about one fourth of the gluten in the wet muslin bag and take it to the laboratory for the chemical tests. Bake the other three fourths in a moderate oven. Result? Take the gluten loaf to the instructor for credit.

2. Place a piece of unbaked gluten about the size of a bean in a test tube; add water and boil. Is gluten soluble in hot water?

3. Place a similar piece in your evaporating dish. Heat and note the odor.

4. Apply the xanthoproteic test. Result?

5. Apply the Millon's test. Result? Is gluten a true protein?

6. *Myosin* is the globulin found in meat. Burn a small piece of meat and note the odor. Apply the xanthoproteic test. Result?

7. *Legumen* is the globulin in peas and beans. Burn half a bean that has soaked overnight. Result? Apply the xanthoproteic test to half a soaked bean. Is a protein present?

B. Albuminoids or Gelatinoids (Soluble in Hot Water, Forming Jellies on Cooling).

Collagen is the protein found in cartilage, skin, and bones.

1. (Instructor's experiment.) Boil for some time a soup bone (chiefly tendons and bone). Strain off the clear liquid and cool it. A jelly is formed.

2. Soak bones in hydrochloric acid for 2 or 3 days or a week. Neutralize the acid with sodium carbonate. Then boil the soft bone. Allow to cool. A jelly is formed. Commercial gelatine is made from bones.

Keratin is a very insoluble protein containing much sulfur. Found in hair, hoofs, and nails.

3. Burn some hairs or feathers and note the odor.

4. Boil some hair or feathers with strong NaOH. Add sodium plumbite solution. A black precipitate of lead sulfide shows the presence of sulfur in keratin.

XI. DIGESTION OF FOOD

The body is composed of water, proteins, fats, and mineral matter. The average daily ration contains about 100 grams of protein, 100 grams of fat, and 420 grams of carbohydrates,

and over a liter of water. Before the proteins of food can enter the blood to build the body, they must be dissolved. Before the fats can enter the blood, they must be emulsified or saponified. Before the carbohydrates can enter the blood to furnish heat and energy to the body, they have to be dissolved and changed to simple sugars. These changes in the food we eat are brought about by various juices in the digestive tract. The process is called *digestion.*

In the study of the digestion of foods the following books are suggested for reference.

1. Appendix in this manual
2. Halliburton, Physiological Chemistry.
3. Snell, Elementary Household Chemistry.
4. Hawk, Practical Physiological Chemistry.
5. Hutchison, Food and Dietetics.
6. Mathews, Physiological Chemistry.

EXPERIMENT 45

Digestion of Starch

MATERIALS. Red litmus paper, Fehling's solution, iodine solution, clean, freshly prepared corn starch paste, pancreatin, bile (ox gall), sodium carbonate solution.

APPARATUS Test tubes, thermometer (Fahrenheit or centigrade), fireless cooker.

A. Action of Saliva on Cooked Starch.

1. Allow some clear saliva to run from the mouth into a clean test tube. Place a piece of red litmus paper in the mouth, and while holding it there test the saliva in the test tube with Fehling's solution. Result?

2. Now remove the litmus paper from the mouth. Is saliva alkaline or acid?

3. Test 1 cc. of freshly prepared corn starch paste with Fehling's solution. Result?

4. Now put about half a teaspoonful of the same paste in the mouth and hold it for a minute. Chew it in order that the starch may be well mixed with the saliva. Note that the taste becomes sweet.

5. Put the paste from the mouth into a test tube. Add Fehling's solution and boil. Result? What is the effect of saliva on boiled starch?

6. What is the source of the saliva? What is the ferment in the saliva that changes the starch? Will this ferment act upon uncooked starch or upon cellulose?

B. Action of Pancreatic Juice on Starch. (Instructor's Experiment.)

The pancreatic juice comes from the pancreas. It acts in the small intestine in an alkaline solution. The ferment in the pancreatic juice that acts upon starch is amylopsin.

1. Dissolve 3 grams of pancreatin in 100 cc. of lukewarm water. Test 3 cc. with iodine and with Fehling's solution. Result?

2. Dissolve 3 grams of bile (ox gall) in 100 cc. of lukewarm water. Test 5 cc. with iodine and with Fehling's solution. Result?

3. Obtain three test tubes. To test tube No 1 add 5 cc. of starch paste and 20 cc. of pancreatin solution. To No. 2 add 5 cc. of starch paste and 20 cc. of bile solution. To No. 3 add 5 cc. of starch paste, 5 cc. of bile, 15 cc. of pancreatin, and 5 cc. of dilute sodium carbonate. Keep all the tubes in a water bath at a temperature of 98° F. or

36.6° C. (temperature of the normal human body) for 24 hours. This can be satisfactorily done by means of a fireless cooker.

4. Remove the tubes. Test the contents of each for starch by the iodine solution and for sugar by means of the Fehling's solution. In which case was digestion most complete? Why?

Questions

1. You eat a piece of cake. Explain all the changes the starch undergoes before it is ready for the blood.

2. Explain what changes cane sugar must undergo before it is digestible. (See Appendix.)

3. Of what use are carbohydrates to the body?

EXPERIMENT 46

Digestion of Proteins

Materials. Minced egg albumen from a hard-boiled egg, pepsin solution prepared by dissolving 1 g. of pepsin in 500 cc. of water, 5 *N* solution of HCl, pancreatin solution prepared by dissolving 1 g. of pancreatin in 500 cc. of water, sodium carbonate solution made by dissolving 1 g. of sodium carbonate in 100 cc. of water.

Apparatus. Test tubes, thermometer, fireless cooker or water oven.

A. **Action of Gastric Juice. (Instructor's Experiment.)**

The saliva has no action on proteins. The gastric juice comes from the walls of the stomach. It consists of water, acids (hydrochloric acid chiefly), and several ferments. The ferments that act upon protein are rennin and pepsin.

1. What is the action of hydrochloric acid upon dissolved

proteins like casein and albumen in milk? (Recall Experiment 43, B, 2.)

2. What is the action of rennin upon such proteins? (See also Experiment 43, B, 2.)

3. Mince well in a clean mortar the coagulated egg albumen of a hard-boiled egg. In each of 4 test tubes place about 3 grams of egg albumen. To tube No. 1 add 20 cc. water. To test tube No. 2 add 20 cc. hydrochloric acid. To No. 3 add 20 cc. of the pepsin solution. To No. 4 add 10 cc. of hydrochloric acid and pepsin.

4. In a fifth test tube place a *lump* of egg albumen. Add 10 cc. of hydrochloric acid and pepsin. This is tube No. 5. Label each tube and keep them all at a temperature of 98° F. (about 37° C.) for 24 hours. To do this put them in a water bath in a fireless cooker or in a water oven.

5. In which tube is the egg albumen most completely liquefied or digested? To what may some of the cases of indigestion be due?

6. Compare tubes No. 4 and No. 5. How is the digestion of proteins affected by insufficient mastication?

B. Action of the Pancreatic Juice.

The ferment in the pancreatic juice which acts upon proteins is trypsin. It acts in an alkaline solution in the small intestine.

1. In each of 3 other test tubes place 3 grams of the minced egg albumen. Number these test tubes No. 6, No. 7, and No. 8 respectively. To No. 6 add 10 cc. of pancreatin solution and 10 cc. of the hydrochloric acid. To No. 7 add 10 cc. of pancreatic and 10 cc. of the sodium carbonate solution. Put these tubes into the same water

bath at 98° F. or 37° C. for 24 hours. To No. 8 add only pancreatin solution.

2. Note results in Nos. 6, 7, and 8. In which tube is digestion most complete?

Questions

1. If you drink a glass of milk, explain all the changes the casein will undergo before it enters the blood. Tell where each change takes place, and the name of the ferments causing it.
2. Of what use are proteins to the body?
3. Explain how fats are digested. (See Appendix.)
4. Of what use are fats to the body?
5. How are the sugars (disaccharids) digested? (See Appendix.)
6. Of what use are the sugars to the body?
7. If you eat ice cream explain completely the digestion of fat, the cane sugar, and the milk sugar.

XII. FOOD ANALYSIS

It would be impossible in a course of this kind to take up in detail the analysis of many foods. Milk is the most common food and possibly the one most subject to adulteration and contamination. Its composition and method of analysis should be understood.

Books of reference:

1. Olsen, Pure Foods.
2. Leach, Food Inspection and Analysis.
3. Sherman, Food Products.
4. Wing, Milk and Its Products.
5. Woodman, Food Analysis.

EXPERIMENT 47

Analysis of Milk

MATERIALS. Whole milk, skimmed milk, dilute hydrochloric acid, litmus, rennin or junket tablets, Fehling's solution.

APPARATUS. Hydrometer, lactometer, hydrometer jars, evaporating dish, balance, centrifugal machine.

A. Specific Gravity of Milk. **(Instructor's Experiment.)**

1. Test the specific gravity of water, whole milk, and skimmed milk with a hydrometer. Which is the heaviest per unit volume? Which is the lightest?

2. Test the specific gravity of water, whole milk, and skimmed milk with a lactometer. Could water be added to skimmed milk till its specific gravity was that of whole milk? Try it.

B. Water in Milk. **(Student's Experiment.)**

1. Weigh an evaporating dish on a balance. Pour about 20 cc. of whole milk into the dish and weigh again. What is the weight of the milk? Heat the milk gently until all the water is evaporated. Do not let it char. Weigh the dish with the residue. Calculate the per cent of water in milk.

2. Tabulate your data thus:

(*a*) Weight of empty dish =—— g.
(*b*) Weight of dish plus milk before evaporating water =—— g.
(*c*) Weight of dish plus residue after evaporating water =—— g.

$(b) - (a) =$ —— g., weight of milk used
$(b) - (c) =$ —— g., weight of water in milk

3. Calculate the per cent of water thus:

Weight of water $\div$ weight of milk

$\times 100 =$ —— % water in milk.

What is the correct per cent of water in milk?

C. Total Solids in Milk (Albumen, Casein, Lactose, Fats, Mineral Matter).

1. From the data in B, 2 above calculate the per cent of total solids in milk, thus:

$(b)-(a)=$ —— g., weight of milk used

$(c)-(a)=$ —— g., weight of residue or total solids

Then, weight of total solids $\div$ weight of milk $\times\ 100=$ —— % of total solids in milk.

2. What is the correct per cent of solids in milk?

3. If the per cent of total solids is less than 12%, what does it indicate?

D. Mineral Matter in Milk.

1. Ignite the residue that remains after evaporating the water in (B) until only a white ash remains. What substances in the residue will burn?

2 Weigh the dish plus ash and call this (*d*).

3. Determine the per cent of ash thus:

$(b)-(a)=$ —— g., weight of milk used

$(d)-(a)=$ —— g., weight of ash

Weight of ash $\div$ weight of milk $\times\ 100=$ % of ash

4. What is the correct per cent of ash in milk?

5. What is the ash in milk chiefly?

E. Fats in Milk. (Instructor's Experiment.)

1. Milk is an emulsion. The small particles of butter fat are held in suspension by the milk albumen and casein. If fresh milk is allowed to stand in a cool place, the butter fat rises, forming a layer of cream. This is the *gravity* method of separating cream from milk.

2. In dairies the cream is separated from the milk more completely and more quickly by the centrifugal cream sepa-

rator. Show the principle of the separator by filling the tubes of a centrifugal machine with whole milk. Operate the machine for five minutes and note the layer of cream in the tubes.

3. If there is a Babcock milk-testing machine in the laboratory, determine the per cent of butter fat in whole milk. (See Experiment 48.)

4. What is the usual per cent of fat in milk?

5. What per cent is required by law in the city?

F. Albumen in Milk. (Student's Experiment.)

1. How would you show the presence of albumen in milk? Recall Experiment 43, A, 7.

2. What is the per cent of albumen in milk?

G. Casein in Milk.

1. To half a test tube of skimmed milk add dilute hydrochloric acid or any dilute acid. Warm. What is the coagulated mass? Recall Experiment 43, B, 2.

2. Test milk with litmus. Result? Now let it stand in a warm place for two or three days till it is thick. Taste it, smell it, and test with litmus. Some of the lactose is changed to lactic acid, which coagulates the casein.

3. Warm 50 cc. of milk in your evaporating dish. Add a little "rennin" or "rennit" or a piece of "junket tablet" about the size of a pin head. Stir till it is dissolved, then cool it. Result? Keep this for H.

4. What is the per cent of casein in milk?

H. Lactose, the Sugar in Milk.

1. Warm the coagulated casein obtained in G, 3 above, then filter the "curd." The greenish liquid obtained as the filtrate is called "whey."

2. Add Fehling's solution to some "whey." Boil. Is lactose present?

3. What is the per cent of sugar in milk?

Questions

1. What is the average composition of cow's milk?
2. Is milk a perfect food for an adult? Why?
3. What is butter?
4. What is buttermilk?
5. What is cottage cheese?
6. How is the ordinary grocery or "cheddar" cheese made?
7. What is evaporated milk?
8. What is ice cream?

EXPERIMENT 48

Babcock Test for Butter Fat in Milk

Note: Four varieties of test bottles are used as follows:

- **a. for whole milk, graduated for 8 % to 10 %.**
- **b. for ordinary cream, graduated for about 30 %.**
- **c. for whipping cream, graduated for 50 %.**
- **d. for skimmed milk, graduated for .5 %.**

MATERIALS. Bottle of whole milk, concentrated sulfuric acid, skimmed milk, canned milk, ordinary cream, whipping cream.

APPARATUS. Babcock test bottles as indicated above, Babcock tester, pipette.

A. Whole Milk.

1. Thoroughly mix the entire bottle or can of milk by pouring back and forth into a beaker several times.

2. Using the pipette, measure 17.6 cc. and deliver into the test bottle *a* (for whole milk). Incline the test bottle so

that the milk will run down one side of the narrow neck while air passes out the other side, to avoid bubbling and loss of milk.

3. Add 17.5 cc. of concentrated sulfuric acid, inclining the test bottle as before and revolving it slowly so that all parts of the neck have the milk washed down.

4. The acid sinks to the bottom. Mix acid and milk by revolving and gentle shaking, being careful not to throw clots back into the neck. The acid dissolves all but the fat and the contents turn dark brown and get hot.

5. Put the bottle into the Babcock testing machine. Fill all the pockets with bottles of milk to be tested or fill the opposite bottles to balance the machine.

6. Whirl 5 minutes at the required speed (80 turns per minute usually). Add hot water to fill the neck of the test bottle. Whirl 2 minutes more.

7. Add hot water to drive all the fat into the neck of the test bottles, but not above the graduations. Whirl one minute more.

8. Read the per cent of fat from the graduated neck while still hot. What is the per cent of butter fat in the sample of whole milk?

B. Ordinary Cream.

1. Put empty test bottle *b* on the scales. Weigh it. Add just 18 grams of thoroughly mixed cream. This is about the amount of cream that the 17.6 cc. pipette will deliver. 9 grams of cream may be used and the result multiplied by 2.

2. Add acid and proceed as for milk. What is the per cent of butter fat in ordinary cream?

C. Whipping Cream.

1. Put empty test bottle *c* on the scales and proceed as for ordinary cream. 9 grams may also be used and the per cent multiplied by 2. What is the per cent of butter fat in whipping cream?

D. Skimmed Milk.

1. Use test bottle *d* with two necks, the larger to deliver materials into the smaller, to read the fractions of per cents as the fat rises. What is the per cent of butter fat in skimmed milk?

E. Canned Milk.

1. Pour out entire contents of the can and mix well.
2. Weigh 9 grams into test bottle *a*. Add 9 cc. of water. Mix thoroughly in the test bottle. Add enough concentrated sulfuric acid to turn the contents dark brown. Proceed as before.
3. If the canned milk is sweetened special precautions may be necessary. (See Leach.) What is the per cent of butter fat in the milk tested?

EXPERIMENT 49

Beverages — Tea, Coffee, Cocoa

REFERENCES:

1. Olsen, Pure Food, pages 110–112.
2. Sherman, Food Products, pages 465–466.
3. Bailey, Sanitary and Applied Chemistry, Chapter XXII.

MATERIALS. Tea, coffee, chocolate, cocoa, ferric chloride, chloroform, iodine solution, sulfuric acid, Fehling's solution, Millon's reagent.

APPARATUS. Beakers, funnels, filter paper, test tubes, graduate, teaspoons, tablespoons, separatory funnel.

Tea

A. Tannin in Tea.

1. Boil 50 cc. of water in a beaker. Add a level teaspoonful of tea and remove from the flame at once. Allow it to stand just five minutes, then filter. Place 5 cc. of the filtrate in a test tube, add 1 cc. of ferric chloride, 25 cc. of water from your graduate. Stir. Keep this test for comparison. What is the dark precipitate?

2. To 50 cc. of boiling water in the beaker add a level teaspoonful of the same tea and boil for five minutes, then filter. Place 5 cc. of the filtrate in a test tube of the same size as that used in A, 1. Add 1 cc. of ferric chloride solution and then 25 cc. of water. Stir. Compare the intensity of color with that of A, 1 and explain. What is the best method of preparing tea? Why?

B. Theine or Caffeine in Tea. (Instructor's Experiment.)

1. Boil three teaspoonfuls of good tea in 100 cc. of water for five minutes, filter, cool, and add 20 cc. of chloroform. Place the mixture in a separatory funnel, shake well for one minute, and then allow the chloroform to settle. Draw it off into a clean beaker and allow it to evaporate at room temperature. Note the pleasant smelling, silky crystals of theine or caffeine. (They are the same chemically.)

C. Questions on Tea.

1. How is green tea prepared for market? Name some varieties of green tea on the market.

2. How does black tea differ from green tea? Name some varieties of black tea on the market.

3. Which contains more tannin, the black or the green tea? Give the reason for your answer.

Coffee

D. Tannin in Coffee.

1. To 200 cc. of cold water in your large beaker add one tablespoonful of well-ground coffee. Slowly bring this to the boiling point and boil for three minutes. Filter. Treat 5 cc. of the filtrate as in A, 1. Keep the test for comparison.

2. Repeat D, 1, but boil for fifteen minutes. Filter and treat 5 cc. of the filtrate as in A, 1. Compare the intensity of color with that of D, 1 and explain. What is the best method of preparing coffee? Why?

E. Caffeine or Theine in Coffee. (Instructor's Experiment.)

1. Add two tablespoonfuls of coffee to 250 cc. of cold water. Bring slowly to the boiling point and boil five minutes. Filter. Cool the filtrate and repeat B, 1. Note the pleasant smelling, silky crystals of caffeine or theine. What is the effect of caffeine or theine upon the human system?

F. Questions on Coffee.

1. How is coffee prepared for market?
2. Why is the coffee bean roasted?

Chocolate and Cocoa

G. Fat in Chocolate and Cocoa.

1. Test both chocolate and cocoa for fat by treating 10 grams of each with 50 cc. of gasoline. Shake well and filter through a dry filter. Allow the gasoline to evaporate. Which contains the most fat?

H. Questions on Chocolate and Cocoa.

1. How is chocolate prepared from the bean for market?
2. How is the beverage made from chocolate?

3. How does the preparation of cocoa on the market differ from that of chocolate?

4. Which beverage is the more nourishing, chocolate or cocoa? Why?

5. For what other purposes are chocolate and cocoa used?

Note: If possible visit a manufacturing house where chocolate and cocoa are prepared from the unroasted beans.

XIII. FOOD ADULTERANTS

The most important food adulterants may be divided into three classes: (1) Substitutes. (2) Artificial Coloring. (3) Preservatives.

References:

1. Leach, Food Inspection and Analysis.
2. E. M. Bruce, Detection of the Common Food Adulterants.
3. Woodman, Food Analysis.
4. Olsen, Pure Foods.

EXPERIMENT 50

Adulterants in Milk

Materials. Milk containing borax or boric acid, another sample containing formaldehyde, limewater, hydrochloric acid, turmeric paper, ferric ammonium alum, concentrated sulfuric acid.

Apparatus. Evaporating dish, test tubes.

A. Substitutes.

1. Cream may be removed and water added until the specific gravity is that of pure whole milk. What should be the per cent of water in whole milk? How can the per cent of water in milk be determined? (See Experiment 47.)

B. Artificial Coloring.

Milk is seldom colored artificially. Annatto or turmeric might be used as in the case of butter and they would be detected in the same way.

C. Preservatives.

1. Borax and boric acid in milk may be detected as follows: Place 20 cc. of milk in an evaporating dish. Add 5 cc. of limewater. Evaporate to dryness. Continue to heat the dish till only a white residue remains. If borax or boric acid was in the milk it will be present in this ash. Dissolve the residue in 1 cc. of dilute hydrochloric acid. Dip a strip of turmeric paper in the solution and dry at 100° *on* a test tube of boiling water. A bright red color indicates the presence of boric acid or borax. The red color is changed to dark green by a drop of ammonium hydroxide.

If there is much borax or boric acid present, the test may be simplified. Acidify the milk with hydrochloric acid. Dip in the turmeric strip. Dry at 100° *on* a test tube of boiling water. A bright red color will appear.

2. Formaldehyde in milk may be detected as follows: Dissolve a crystal of ferric ammonium alum (about the size of a pea) in about 1 cc. of water. *Carefully* add 1 cc. of concentrated sulfuric acid. Pour this solution carefully down the side of an inclined test tube containing about 10 cc. of the milk to be tested. A violet coloration is produced at the junction of the two liquids if formaldehyde is present. Warm over the Bunsen burner if necessary.

If possible visit a large dairy or creamery and note particularly the precautions taken for the sake of cleanliness.

EXPERIMENT 51

Test for Adulterants in Butter

MATERIALS. Pure butter, oleomargarine, ice water, sweet milk, carbon disulfide, ethyl alcohol, hydrochloric acid, ammonium hydroxide, concentrated sulfuric acid, white woolen yarn, turmeric paper.

APPARATUS. Test tubes, beakers, pine splints.

A. Detection of Substitutes.

1. In two separate test tubes place 5 grams of pure butter and 5 grams of oleomargarine or renovated butter. Heat each over the Bunsen burner. The pure butter melts quietly, producing much foam, while the renovated butter or oleomargarine sputters and crackles and produces very little foam. This is called the foam test for butter.

2. In two separate small beakers place 5 grams of pure butter and of oleomargarine. Add to each about 25 cc. of sweet milk and warm gently till the samples are melted. Then place the beakers in ice water and stir constantly with pine splints till the fat solidifies. In the case of oleomargarine the fat will collect in a lump which may be lifted out by the stick, while pure butter or renovated butter will form an emulsion with the milk resembling cream.

3. Given an unknown sample, how would you proceed to determine whether it was oleomargarine, renovated butter, or real butter?

B. Detection of Artificial Coloring in Butter.

1. To 5 grams of butter in a large test tube add 4 grams of carbon disulfide and 30 grams of ethyl alcohol. Shake well and allow the mixture to stand till it separates into

two layers. The lower layer is the carbon disulfide containing the butter fat in solution. The upper layer is alcohol, which dissolves the dye and is colored by it. If the alcohol layer is colorless, the butter contains no artificial coloring.

If the alcohol layer is colored, test for artificial dyes as follows:

2. Turmeric: To 5 cc. of the alcohol layer add ammonium hydroxide. If a brown color is produced, turmeric was used to color the butter.

3. Annatto: Evaporate 10 cc. of the alcohol layer to dryness with a low Bunsen flame. Add a drop of concentrated H_2SO_4 to the residue. A greenish blue coloration indicates the presence of annatto.

4. Coal-tar dyes: To 10 cc. of the alcohol extract add 10 cc. of water. Add 1 cc. of HCl and a piece of white woolen yarn. Boil. If the yarn is colored the presence of coal-tar dyes is shown.

C. Preservatives in Butter.

1. The preservative most often used is boric acid. To 10 grams of butter add 10 cc. of water and boil. Pour off the melted fat. To the water remaining add 1 cc. of HCl. Dip a strip of turmeric paper into the solution and dry on a test tube of boiling water. A cherry red color denotes the presence of boric acid. Add a drop of ammonia to the colored paper. Result?

Questions

1. How is pure butter made?
2. What is "renovated butter"?
3. What is oleomargarine?

EXPERIMENT 52

Adulterants in Jellies and Candies

MATERIALS. Jellies, candies, iodine solution, acid mercuric nitrate (see Appendix), picric acid solution, 4 *N* hydrochloric acid, white woolen yarn or strips of white woolen cloth.

APPARATUS. Test tubes, beakers.

A. Substitutes.

1. *Starch:* Boil about 5 grams of jelly with water, cool, and add a solution of iodine. The usual dark blue color indicates the presence of starch.

Test cheap candies for starch.

2. *Gelatin:* Put 1 cc. of jelly in a test tube. Add 10 cc. of water. Warm till the jelly is dissolved. Cool. Add an equal volume of acid mercuric nitrate and 20 cc. of cold water. Shake well and allow it to stand for five minutes. Filter. If gelatin is present the filtrate will be cloudy. To confirm the test add 1 cc. of saturated water solution of picric acid to a portion of the filtrate. If gelatin is present, a yellow precipitate will be formed. Test candy in the same way.

B. Artificial Coloring.

Artificial jams and jellies are often colored with anilin dyes to imitate the natural fruit product, therefore a test for the dyes indicates the character of the product.

1. Dissolve about 15 grams of the jelly in 100 cc. of water. Filter if necessary. Add 1 cc. of 4 *N* hydrochloric acid. Place in it strips of white woolen cloth or woolen yarn and boil for five minutes. Now remove the strips and wash them in cold water and then boil again in a very dilute solution of hydrochloric acid. If the strip has a dull color the coloring

matter in the jelly was due to the natural coloring in the fruit. If the strip is brightly colored, anilin dyes were present. Paste the strip in the notebook.

2. In like manner test candies for the presence of anilin dyes. Paste the strip in the notebook.

C. Preservatives.

1. Candies and jellies are naturally preserved by the sugar present.
2. By what four methods may foods be preserved?
3. Describe briefly each method.
4. Which methods are harmless?
5. Which are not? Why?
6. How are pure jellies prepared?
7. How are pure candies prepared?

XIV. FOOD VALUES

Food is any substance which when taken into the body supplies it with heat and energy or builds tissue.

There are five classes of food principles: proteins, fats, carbohydrates, mineral matter, and water. Proteins, mineral matter, and water are the tissue builders. Fats and carbohydrates furnish heat and energy. Proteins, fats, and carbohydrates are called the *nutritive constituents* of foods.

These nutritive constituents oxidize or burn in the body and produce heat. The amount of heat so produced has been found to be the same as the heat produced by the substances if burned outside the body in the laboratory. When burned in the laboratory the heat produced is measured in calories. A calorie is the amount of heat necessary to raise a kilogram of water 1° C. (large calorie).

In the back of this Manual, you will find approximately the food value in calories necessary for a girl (woman) of your weight. There are also tables showing the portion of ordinary foods that contain 100 calories of heat.

EXPERIMENT 53

Menu Making

A. Daily Menu.

1. From the Appendix find the calories (food units) required for your weight, calories furnished by protein, fat, and carbohydrate.

2. One fourth of this amount should be furnished by the breakfast, one fourth by the lunch, and one half by the dinner.

3. Now prepare a menu for a day for yourself, using the following as a model:

Daily Menu

Weight 159 lb. requires 239 calories protein, 717 calories fat, 1434 calories carbohydrate, total 2390 calories, $\frac{1}{4}$ for breakfast, $\frac{1}{4}$ for lunch, $\frac{1}{4}$ for dinner.

Meals	Calories Protein	Calories Fat	Calories Carbohydrates	Total Calories
Breakfast	61	176	350	587
Lunch	58	175	360	593
Dinner	120	350	725	1195
Total calories	239	701	1435	2375

B. Dinner Menu.

1. Make a dinner menu giving careful attention (*a*) to the correct number of calories as found in A, and (*b*) to the current market prices of foods, making the total cost of the dinner as low as possible. Tabulate as follows:

Dinner Menu

Food	Portion	Ounces	Cost	Calories Protein	Calories Fat	Calories Carbohydrate
Lamb, leg, roasted, etc.	Ord. serving	1.8	.05	40	60	C0
Total						

XV. LEAVENING AGENTS

A leavening agent is a substance which, when put into a dough, usually forms carbon dioxide. This gas "lightens" the dough.

Yeast is the oldest leavening agent. It changes starch and sugar to carbon dioxide and alcohol.

Baking soda is sodium bicarbonate, $NaHCO_3$. It may be used in dough with some substance that contains an acid, such as sour milk or molasses. Baking powder is a mixture of powdered sodium bicarbonate with a powdered acid or acid principle, such as tartaric acid or an alum, with starch to keep the mixture dry.

EXPERIMENT 54

Products of Yeast Fermentation

MATERIALS. Yeast cake (compressed), molasses, limewater.

APPARATUS. 250 cc. flasks, test tube, delivery tube, distilling flask, condenser, thermometer, liter beaker.

A. Carbon Dioxide.

Note: Two students work together.

1. Mix about one fourth of a cake of compressed yeast with 15 cc. of water in the evaporating dish. Stir till a

smooth mixture is formed. Pour the yeast mixture into a flask containing 25 cc. of molasses and 100 cc. of water.

2. Note the odor and taste of the mixture.

3. Fit a one-holed stopper and a delivery tube to the flask containing the mixture. Let the other end of the delivery tube dip into a flask containing limewater.

4. Put the flasks in the sun or a warm place.

Begin Experiment 55.

5. At the end of two hours examine the liquid and limewater. Is the yeast working? What gas caused the change in the limewater? Write the equations and name all substances:

$$CO_2 + Ca(OH)_2 \longrightarrow CaCO_3 + H_2O$$

6. What effect has a very low temperature upon fermentation? Why are fresh vegetables, fruits, milk, and butter kept in a refrigerator?

7. Boil 10 cc. of the fermenting yeast mixture. Cool again to room temperature. Does fermentation continue? Why? Why do jars of canned fruit sometimes ferment? If these fruits are reheated soon after fermentation begins, they may be used. Why?

B. Alcohol.

1. At the end of 12 hours examine the mixture. Has fermentation ceased? Why?

2. Note the odor and taste of the mixture. What new substance is present? The sugar in the molasses is changed to alcohol and carbon dioxide. Write the equation and name all substances.

$$C_6H_{12}O_6 + \text{yeast} \longrightarrow 2\ C_2H_5OH + 2\ CO_2$$

Note: Empty the mixture in your flask into the liter beaker provided. The teacher will distill half of this for alcohol, the other half should be labeled and set aside for a week or more for part C.

3. (Instructor's experiment):

Distill about 500 cc. of the fermented molasses, using a water bath. Collect the fraction that comes over below 79° C. What is this distillate chiefly?

4. Note the odor of the distillate.

5. Apply a lighted match to 1 cc. of it. Does it burn?

6. What is formed when fruit juices containing sugar ferment? Where does the yeast that causes the fermentation come from?

7. How does yeast leaven bread dough?

C. Vinegar.

1. Note the odor and taste of the yeast molasses mixture that has been allowed to stand for several weeks. What is the substance?

2. How could vinegar be made at home from fruit parings?

3. What is "sweet cider"?
   What is "hard cider"?
   What is "cider vinegar"?

EXPERIMENT 55

Baking Soda, Baking Powder

MATERIALS. Dilute hydrochloric acid, sulfuric acid, sodium bicarbonate, molasses, sour milk, powdered tartaric acid, cream of tartar, acid calcium phosphate $H_4Ca(PO_4)_2$, ammonium alum, any baking powder (composition unknown to student), 6 common baking powders with labels, iodine solution, barium chloride solution, ammonium molybdate solution.

APPARATUS. Test tubes, beakers, funnel, filter paper.

A. Baking Soda (Sodium Bicarbonate, $NaHCO_3$).

1. Put 15 cc. of dilute hydrochloric acid in a beaker. Add 1 gram of sodium bicarbonate. What gas is evolved? Write the equation, naming all substances:

$$HCl + HNaCO_3 \longrightarrow NaCl + CO_2 + H_2O$$

2. Dissolve 5 cc. of molasses in 15 cc. of water in a beaker. Add 1 gram of sodium bicarbonate. Result? What is the acid in molasses?

3. Repeat (2), using sour milk. Result? What is the acid in sour milk?

4. How is "soda" used to leaven a dough?

B. Baking Powders.

1. *Tartrate baking powders.*

a. Make a tartrate baking powder by mixing a gram of tartaric acid ($H_2C_4H_4O_6$) with a gram of sodium bicarbonate ($NaHCO_3$). Add 15 cc. of water. Result? What is the gas evolved? Write the reaction and name all substances:

$$H_2C_4H_4O_6 + 2\ NaHCO_3 \longrightarrow Na_3C_4H_4O_6 + 2\ H_2O + 2\ CO_2$$

b. Make a tartrate baking powder by mixing cream of tartar (acid potassium tartrate, $HKC_4H_4O_6$) with the soda. Add water as before. Result? Write the equation and name all substances:

$$HKC_4H_4O_6 + HNaCO_3 \longrightarrow KNaC_4H_4O_6 + H_2O + CO_2$$

2. *Phosphate baking powders.*

Repeat B, 1, using acid calcium phosphate, $H_4Ca(PO_4)_2$, with the soda. Write the equation and name all substances:

$$H_4Ca(PO_4)_2 + 2\ HNaCO_3 \longrightarrow HNa_2PO_4 + HCaPO_4 + 2\ H_2O + 2\ CO_2$$

3. *Alum baking powders.*

Repeat B, 1, using, instead, powdered ammonium alum, $NH_4Al(SO_4)_2$, with the soda. Write the equation and name all substances:

$$2\,NH_4Al(SO_4)_2 + 6\,HNaCO_3 \longrightarrow 2\,Al(OH)_3 + (NH_4)_2SO_4 + 3\,Na_2SO_4 + 6\,CO_2$$

4. Why is baking powder such a useful leavening agent?

5. Which baking powder is considered most efficient of the three mentioned? Why?

C. Tests for Baking Powders.

A baking powder may be a tartrate baking powder, or an alum powder or a phosphate powder or a mixture of two or three of these powders. Test an unknown baking powder to determine its nature as follows:

1. Put 15 grams of the baking powder into a beaker and pour over it 50 cc. of water. Stir until no more gas is evolved, then filter carefully.

2. Starch is insoluble in cold water and will remain on the filter paper as a white residue. Make the usual starch test on this residue. Result?

3. If the baking powder contains alum, the filtrate will contain sulfates. To 5 cc. of the filtrate add 5 cc. of hydrochloric acid and 5 cc. of barium chloride solution. A white precipitate indicates sulfates. Is the sample an alum baking powder?

4. If the baking powder is a phosphate baking powder, the filtrate will contain acid calcium phosphate. Test 5 cc. of the filtrate for a phosphate by adding a few drops of nitric acid, then heat nearly to boiling and add a few drops of this hot mixture to 5 cc. of ammonium molybdate solution. A

yellow precipitate shows the presence of phosphates. Is the sample a phosphate baking powder?

5. To test for a tartrate baking powder, pour 5 cc. of the filtrate into an evaporating dish. Add 5 drops of sulfuric acid and evaporate to dryness. Heat gently and note the odor of burning sugar if a tartrate is present. Is the sample a tartrate baking powder?

6. Examine labels of 6 different baking powders on the market and note the ingredients of each.

XVI. TEXTILES

The chief fibers of vegetable origin are cotton and linen. The important fibers of animal origin are wool and silk.

REFERENCE:

1. Woolman and McGowan, Textiles.

EXPERIMENT 56

Cotton, Linen, Wool, and Silk

MATERIALS. Cotton, linen, wool, and silk textiles, 5% solution of KOH, concentrated HCl, Loewe's solution.

APPARATUS. Microscope, forceps.

A. **Microscopic Tests.**

1. Examine raveled samples of cotton, linen, wool, and silk fibers under the microscope. Draw each fiber and label it.

B. **Burning Test.**

1. Hold a strip of wool with the forceps and ignite it in the Bunsen flame. Note the odor and appearance as it burns.

2. Repeat, using strips of silk, cotton, and linen. Note

the odor and appearance of each as they burn. Which of the fibers may be detected by its odor in burning?

C. To Distinguish Silk and Wool from Cotton and Linen.

1. Boil about one square inch of woolen textile in a beaker containing 10 cc. of a 5% solution of KOH. Result?

2. Repeat (1), using silk, cotton, and linen in separate beakers. Note results in each case.

3. Many so-called woolen textiles contain cotton. To detect the presence of cotton cut two samples of the material 2 by 2 inches; mount the first one. Boil the second sample for 10 minutes with a 5% solution of KOH. If the wool is pure, there will be no residue. If a residue is left, mount it, and explain the result. Record results as follows:

Sample of wool used for experiment.	Sample of same material boiled 10 minutes in 5% KOH.
a	*b*

D. To Distinguish Wool from Silk.

1. In a beaker containing 20 cc. of concentrated HCl place a strip of wool and one of silk and boil for two minutes. Which is dissolved?

2. Cut 2 samples of material supposed to be a mixture of wool and silk. Mount one sample. Treat the other as in 1.

Pure silk will dissolve in concentrated hydrochloric acid. If it is weighted, a residue remains. If wool is present, the fibers will be undissolved. Wash, dry, and mount the sample, unless it is entirely dissolved.

Sample of material used.	Sample in concentrated HCl for 2 minutes.
a	*b*

E. To Distinguish Cotton from Silk.

1. In a beaker containing 20 cc. of Loewe's Reagent place a strip of cotton and one of silk. Which fibers dissolve?

2. Artificial silks are usually cellulose. How would you distinguish real silk from artificial silk?

DYEING

When a colored substance is attached to the fibers of the textile in such a way that it is not removed by rubbing or washing or by the sunlight, the textile is *dyed.*

Several of the metallic hydroxides are used as *mordants* in dyeing. They form insoluble precipitates, called *lakes,* with dyes. When these lakes are formed in the fibers of the textile, the dye is *fixed* and the colors are *fast.*

A dye that will dye textiles without the use of a mordant is called a *direct dye.* A dye that will not dye textiles without the use of a mordant is called a *mordanted dye.*

REFERENCE: Woolman and McGowan, Textiles.

EXPERIMENT 57

Textile Dyeing

MATERIALS. Dilute ammonium hydroxide, aluminum sulfate, 5 % logwood solution (see Appendix), alizarin, strips of cotton cloth 1 inch by 3 inches from which sizing has been removed by boiling in a 2 % solution of sodium carbonate for 5 minutes, Congo red solution prepared by dissolving in 200 cc. distilled

water, 1 g. sodium carbonate, 2 g. sodium sulfate, and 2 g. Congo red.

APPARATUS. Test tubes, enameled pans or beakers for the color baths.

A. Mordants and Lakes.

1. Add 5 cc. of dilute ammonium hydroxide to 10 cc. of aluminum sulfate solution. The gelatinous precipitate is aluminum hydroxide. Write the equation for the reaction. Add 2 cc. of logwood solution. Shake the tube well and let it stand. Is the dye held by the precipitate? This colored precipitate is called a *lake*. The aluminum sulfate is a *mordant.*

2. Repeat A, 1, using 2 cc. of alizarin instead of the logwood solution. Let the tube stand. Result?

B. Use of Mordants in Dyeing.

1. Boil in a logwood solution for five minutes a strip of cotton cloth from which the sizing has been removed. Remove, wring, and wash thoroughly. Does the color wash out? Dry the strip and mount it in your notebook.

2. Mordant a piece of cotton cloth by boiling it in 20 cc. of aluminum sulfate solution. Wring out and let it stand in warm, dilute ammonium hydroxide for five minutes. Wring it out.

Now boil this mordanted strip in a logwood solution for five minutes. Wring out and wash thoroughly. Does the color wash out?

Paste the strip in your notebook.

3. Repeat B, 1, using an unmordanted (wet) strip in alizarin. Wash, dry, and mount in your notebook.

4. Repeat 3, using a mordanted strip (wet) prepared as in B, 2, and alizarin. Paste the strip in your notebook.

C. Direct Dye for Cotton.

1. Place a wet piece of cotton cloth (unsized) in 20 cc. of prepared Congo red solution and boil 5 minutes. Remove the cloth, wash, dry, and mount it in your notebook.

CLEANING OF FABRICS

Many useful books are now on the market that explain in detail the removal of spots and stains from fabrics. A few principles of stain removing will be outlined.

REFERENCE: Woolman and McGowan, Textiles.

EXPERIMENT 58

Removing Spots and Stains

MATERIALS. Strips 3 inches by 4 inches of white cotton cloth stained with (*a*) blood, (*b*) another set of strips stained with coffee, (*c*) with spots of fruit juice, (*d*) with chocolate, (*e*) with grease, (*f*) with paint, (*g*) vaseline, (*h*) ink stains; hydrogen peroxide, ammonium hydroxide, Javelle water (see Appendix), borax, gasoline, carbon tetrachloride, absorbent cotton or blotters, soap, turpentine, bleaching powder, dilute hydrochloric acid, oxalic acid, Ink Eradicator (see Appendix).

APPARATUS. Beakers.

A. Stains Removed by Cold Water.

For blood and stains of a protein nature, also for unknown stains, use cold water. The cloth is placed over a bowl or some convenient vessel and water poured first *around* the stain, then on it.

1. Remove a *blood stain* by this method, or if the stain is old, lukewarm water and soap will remove it more quickly.

B. Stains Removed by Hot Water.

Hot water is used for colors held in a sugary solution and for glue. Sometimes if the stain is old, a bleach or some substance that will react with the coloring matter should be used with the hot water.

1. Remove a *coffee stain* by putting the spot over a beaker and then pour boiling water first around the spot, then on it. If it is not removed, try hydrogen peroxide, alkaline with ammonia, on the spot; then add hot water. Or soak in weak Javelle water for a few minutes and rinse with boiling water.

2. Remove a *fruit stain* by the method of B, 1.

3. Remove a *chocolate* or *cocoa stain* by covering stain with borax. Soak in cold water, then pour on hot water.

C. Stains Removed by Solvents.

Spots produced by grease, vaseline or waxes, paint, varnish, or tar cannot be removed by water. Grease and waxes are soluble in chloroform, carbon tetrachloride, ether, gasoline, or benzene. Paint, varnish, or tar should be treated with turpentine, then with one of the solvents above.

1. Remove a *grease spot* by carbon tetrachloride. Place absorbent cotton or a blotter under the spot and rub the solvent from the outside toward the center of the spot. Follow with warm soap and water.

2. Remove a *paint stain* by using turpentine, then gasoline or carbon tetrachloride.

3. Remove *vaseline* by soaking in kerosene first, then wash with soap and water.

D. Stains Removed by Chemical Treatment.

Such stains as iron rust, ink, acid stains, grass stains, and mildew need a special bleach or other chemical treatment.

1. Remove an *ink stain*, if fresh, by cold water. Or apply alternately solutions of bleaching powder and dilute hydrochloric acid or oxalic acid. Or apply Javelle water or ink eradicator prepared.

E. For the removal of other stains see the following table:

Kind of Stain	Reagent Used
Fruit, tea, or coffee	1. Boiling water, if stain is fresh. If old, use bleaching powder and a little acetic acid or hydrogen peroxide and hot water. 2. Javelle water.
Grass	1. Alcohol or ammonia. 2. Javelle water.
Grease	1. Gasoline. 2. Carbon tetrachloride Follow with soapsuds and ammonia.
Vaseline	Kerosene; follow with warm soap solution.
Tar	1. Benzol. 2. Turpentine; follow with soap and ammonia.
Paint	1. Carbon tetrachloride. 2. Turpentine; follow with soap and ammonia.
Varnish	Equal parts of wood alcohol, benzol, and acetone.
Acids, hydrochloric, sulfuric	Ammonia in each case.
Iron rust	1. Oxalic acid. Afterwards wash out acid with hot water. 2. Salt and lemon juice, or citric acid.
Ink	1. Sweet milk on colored goods. 2. Salt and citric acid. 3. Oxalic acid. 4. Ink eradicator or Javelle water.
Iodine	1. Alcohol. 2. Sodium thiosulfate.

Kind of Stain	Reagent Used
Mildew	Soapsuds. Tartaric acid followed by Javelle water. Sunlight.
Blood	Wash with cold or lukewarm water and soap.
Sugar, glue	Wash with hot water.

EXPERIMENT 59

Bleaching and Blueing

Materials. Strips of colored calico, 3 inches by 1 inch, fresh bleaching powder, dilute hydrochloric acid 10 %, sodium thiosulfate solution, sodium sulfite, strips of colored woolen cloth, 3 inches by 1 inch, colored feathers or ecru silk strips, 3 inches by 1 inch, aniline blue, oxalic acid solution 10 %, sodium hydroxide solution, Prussian blue, Ultramarine, Indigo.

Apparatus. Beakers, 300 cc. bottle with cork to fit.

A. To Bleach Cotton or Linen.

1. Obtain 2 strips of colored calico. Keep one to mount later and put the other in a beaker containing a thin paste of 5 grams of fresh bleaching powder (calcium hypochlorite) and 100 cc. of water. Remove the strip and dip it into a beaker containing 25 cc. of hydrochloric acid. Dip the strip into the bleaching powder again, and again into the acid till it is bleached.

2. The acid liberates the chlorine from the bleaching powder. Write the equation. The chlorine bleaches cotton or linen, but it yellows wool or silk. Dip the strip into a 5 % solution of sodium thiosulfate, which destroys the chlorine remaining on the cloth and prevents the fiber from being weakened. Wash the strip, dry it, and mount it in your notebook with the unbleached sample.

3. Javelle water is often used for bleaching cotton or linen at home. It is a solution of sodium hypochlorite ($NaOCl$) and its bleaching action is similar to that of bleaching powder.

B. To Bleach Wool or Straw.

1. Put 5 grams of sodium sulfite (Na_2SO_3) in a 300-cc. bottle and fit it loosely with a stopper. Hang a strip of colored woolen cloth so that it is suspended in the bottle when the stopper is inserted. Add 25 cc. of dilute hydrochloric acid to the bottle, insert the stopper loosely, and let it stand. The gas liberated is sulfur dioxide. Write the equation. Sulfur dioxide bleaches cotton, straw, or silk as well as wool. Mount an unbleached and a bleached sample of the woolen cloth in your notebook.

C. To Bleach Feathers, Hair, or Silk.

1. To 10 cc. of hydrogen peroxide in a beaker add ammonium hydroxide little by little till bubbles of oxygen begin to form. Immerse a piece of ecru silk or a colored feather. Leave them till they are bleached.
2. Mount the bleached and the unbleached sample.

D. Blueing.

In addition to bleaching, yellowish goods may be given a white appearance by "blueing." There are two classes of blueings: (1) Liquid blueings or those apparently *soluble* in water and sold in bottles, *i.e.* anilin blues and Prussian blue. (2) Solid blueings or those insoluble in water, *i.e.* ultramarine and indigo.

1. Liquid blueing — *Anilin blue.*

Obtain 10 cc. of anilin blue. To half of it add 5 cc. of

oxalic acid solution. The intensity of the blue color is deepened. This acid is sometimes used in the laundry. What harm does it do to textiles? Add 5 cc. of sodium hydroxide to the other half. It usually turns red. What danger is there in leaving soap in the goods? The anilin blueing is cheap and satisfactory if used with care.

2. Liquid blueing — *Prussian blue.*

Obtain 10 cc. of Prussian blue. Add 10 cc. of dilute sodium hydroxide. The red or yellow precipitate is ferric hydroxide, which is *iron rust.* If soap or soda were in the clothes to be "blued" with Prussian blue, what would probably be the result?

3. Solid blueing — *Ultramarine.*

Usually comes in balls. Obtain a portion of a ball and stir it in water. It is insoluble in water, but is so finely divided that if carefully used does not *streak* the goods. It is not affected by soap or soda.

4. Solid blueing — *Indigo.*

Usually in balls. It is expensive. It is insoluble and apt to streak the goods unless used carefully. It is not affected by soap or soda or light. Obtain some indigo and put a little into some water. Note the intense blue color.

SOAP

Ordinary hard soap is usually a mixture of the sodium salts of several organic acids, one of which is stearic acid, $C_{17}H_{35}COOH$. The soap sodium stearate would then have the formula $C_{17}H_{35}COONa$. Soaps are made by the action of sodium or potassium hydroxide on fats. Fats are solid esters formed by the action of the alcohol glycerin $C_3H_5(OH)_3$ on

several organic acids, one of which is stearic acid. The fat glyceryl stearate is $(C_{17}H_{35}COO)_3C_3H_5$.

Reference: Any organic chemistry or any elementary chemistry. See also page 155 of the Appendix.

EXPERIMENT 60

Soaps, Cleansing Powders

MATERIALS. Cottonseed oil, alcohol, 40% solutions of sodium hydroxide, alcoholic solution of phenolphthalein, toilet soap, laundry soap, solution of castile soap, calcium chloride solutions, Sapolio or other scouring soap, Dutch Cleanser or other cleansing powder.

APPARATUS. 500-cc. flask fitted with a one-hole rubber stopper and a straight glass tube 1 yard long, large evaporating dish, test tubes, beakers, funnel, filter paper.

A. Preparation of Soap. (Instructor's Experiment.)

1. Pour 50 cc. of cottonseed oil into a 500-cc. flask. Add 100 cc. of alcohol and 15 cc. of a 40% solution of sodium hydroxide. Place the stopper with the long glass tube (reflux air condenser) in the flask, and heat for an hour or more. The alcohol condenses in the tube and runs back into the flask. Alcohol is not needed to make soap but it dissolves both the oil and the hydroxide and so causes the action between them to be more rapid.

2. Pour the mixture into a large evaporating dish or enamel pan and heat till the alcohol is driven off. Stir constantly. Cool the mixture. The solid substance is soap. Write the equation for the making of soap. Name all substances:

$$(C_{17}H_{35}COO)_3C_3H_5 + 3\ NaOH \longrightarrow C_3H_5(OH)_3 + 3\ C_{17}H_{35}COONa$$

3. Shake some of this prepared soap with distilled water. Does it produce suds?

B. Properties of Soap. (Student's Experiments.)

1. Free alkali in soap.

Cut a piece of dry toilet soap and add to the freshly cut surface a few drops of an alcoholic solution of phenolphthalein without water. If a red color appears, free alkali is present. In the same way test a piece of laundry soap for free alkali. Why should woolen goods not be washed with a soap containing free alkali?

2. Free fat in soap.

Shake a few shavings of dry soap in a test tube with 20 cc. of gasoline. Filter into a beaker. Allow the gasoline to evaporate. A greasy residue indicates unsaponified fat.

3. Water in soap.

Place a few shavings of a fresh soap in a large test tube. Heat the tube gently and look for drops of water on cool sides of tubes. Result? Is it wise to buy a cheap, soft, highly scented or colored soap? Why?

4. Action of soap in hard water.

If soap is added to a solution of a calcium or magnesium salt, an insoluble calcium or magnesium soap is formed. Hard water contains salts of calcium and magnesium and such waters form a curdy precipitate when soap is added.

To 20 cc. of distilled water add 5 cc. of a pure castile soap solution. Shake and note the suds. Now add 5 cc. of a solution of calcium chloride. What is the white precipitate? Shake. Are suds formed?

Write the equation and name all substances:

$$2\ C_{17}H_{35}COONa + CaCl_2 \longrightarrow 2\ NaCl + (C_{17}H_{35}COO)_2Ca$$

C. Water Softeners.

1. When may water be made "soft" by boiling? Explain. Write equation.

2. Washing soda, Na_2CO_3, will precipitate calcium or magnesium salts in hard water as carbonates, thus removing the "hardness." Write equations to show.

Test a soap powder for sodium carbonate by adding hydrochloric acid to 5 grams in a test tube and observe effervescence. Result? Test also a hard water soap. Result?

Note: There are many water softeners on the market; sodium carbonate, sodium phosphate, or sodium silicate are often the chief constituents. The action of these is to precipitate the calcium or magnesium salts as insoluble carbonates, phosphates, or silicates.

D. Scouring Soaps and Cleansing Powders.

1. Boil 10 grams of a scouring soap, such as Sapolio, or a cleansing powder such as Dutch Cleanser, in a beaker with 50 cc. of water. Filter.

2. Add dilute hydrochloric acid to the residue. If it effervesces, insoluble carbonates are indicated. Result?

3. The residue insoluble in dilute acid may be clay, fine sand, or pumice. Note your sample.

4. Add dilute hydrochloric acid to the filtrate. Effervescence indicates sodium carbonate. Result?

APPENDIX

THE METRIC SYSTEM

This is the system used by scientists. It is used by everyone in most of the countries of Europe and, because of its convenience, is being used more and more in the United States and Great Britain.

1. Length:

The unit is the meter. It is equal to 39.37 inches or 1.1 yards. The centimeter is the unit of length most used by the chemist. It is $\frac{1}{100}$ of a meter, or $\frac{2}{5}$ of an inch.

10 millimeters (mm.)	=1 centimeter (cm.)
10 centimeters	=1 decimeter (dm.)
10 decimeters	=1 meter (m.)
1000 meters	=1 kilometer (km.)

2. Volume:

The unit used by the chemist is either the *cubic centimeter* or the *liter*. The volume of a flask may be given as 500 cc. or $\frac{1}{2}$ liter. One U. S. liquid quart = 946.36 cubic centimeters, a little less than a liter.

1000 cubic millimeters	=1 cubic centimeter (cc.)
1000 cubic centimeters	=1 cubic decimeter
1000 cubic decimeters	=1 cubic meter

3. Weight:

The unit is the gram. This is the weight of 1 cc. of pure water at its temperature of greatest density, 4° C.

10 milligrams (mg.)	=1 centigram (cg.)
10 centigrams	=1 decigram (dg.)
10 decigrams	=1 gram (g.)
1000 grams	=1 kilogram (kg.)

The gram and the kilogram are the units of weight most generally used by the chemist.

One ounce avoirdupois	=	28.35	grams
One pound avoirdupois	=	453.59	grams
One kilogram	=	2.2	pounds

TEMPERATURES

Centigrade and Fahrenheit and Absolute Scales

The *Centigrade Thermometer* is the one used in scientific work. The abbreviation for centigrade is *C*. The boiling point of water on this thermometer is marked 100 and the freezing point is marked 0. The 100 equal divisions between these points are called degrees. The abbreviation for degrees is °. The boiling point of water is written 100° C. Degrees below zero are written as minus; thus, $-20°$ C. means 20° below zero.

The *Fahrenheit Thermometer* is the one commonly used in this country. On this thermometer the boiling point of water is 212° F. and the freezing point of water is 32° F. above zero.

To change the Fahrenheit degrees to centigrade degrees, subtract 32 and multiply the remainder by $\frac{5}{9}$, thus:

$$\text{C.} = \tfrac{5}{9}\,(\text{F.} - 32)$$

To change centigrade degrees to Fahrenheit degrees multiply by $\frac{9}{5}$ and add 32 to the product, thus:

$$\text{F.} = \tfrac{9}{5}\,\text{C.} + 32$$

The Absolute Temperature is the one used by scientists in the study of gas volumes.

The point $-273°$ C. is called the absolute zero. Absolute temperature is reckoned from this point. Degrees on the absolute scale are found by adding 273 to the readings on the centigrade thermometer. Thus:

$$10°\ \text{C.} = 10° + 273° = 283°\ \text{T.}$$
$$-60°\ \text{C.} = -60° + 273° = 213°\ \text{T.}$$

LIST OF THE COMMON ELEMENTS, THEIR SYMBOLS, ATOMIC WEIGHTS, AND VALENCES

O = 16

Name	Symbol	Valences	At. Wt.	Name	Symbol	Valences	At. Wt.
Aluminum	Al	3	27.1	Nickel . .	Ni	2–3	58.7
Antimony .	Sb	3–5	120.2	Nitrogen	N	3–5	14
Arsenic . .	As	3–5	75	Oxygen .	O	2	16
Barium .	Ba	2	137.4	Phosphorus	P	5–3	31
Bismuth .	Bi	3	208	Potassium	K	1	39.1
Boron . .	B	3	11	Silicon .	Si	4	28.3
Bromine .	Br	1–5	79.9	Silver . .	Ag	1	107.9
Cadmium .	Cd	2	112.4	Sodium .	Na	1	23
Calcium .	Ca	2	40.1	Sulfur . .	S	2–4–6	32.1
Carbon .	C	4–2	12	Tin . .	Sn	2–4	119
Chlorine .	Cl	1–5–7–3	35.5	Zinc . .	Zn	2	65.4
Chromium	Cr	3–6–7–2	52				
Cobalt . .	Co	2–3	59				
Copper . .	Cu	2–1	63.6				
Fluorine .	F	1	19				
Gold . .	Au	1–3	197.2				
Hydrogen .	H	1	1				
Iodine . .	I	1–5–7	127				
Iron . . .	Fe	3–2	55.9				
Lead . .	Pb	2–4	207.1				
Magnesium	Mg	2	24.3				
Manganese	Mn	2–7–4–6–3	54.9				
Mercury .	Hg	2–1	200.6				

THE WEIGHT IN GRAMS OF 1 LITER OF VARIOUS GASES MEASURED UNDER STANDARD CONDITION (0 DEGREES C. AND 760 MM. PRESSURE)

Acetylene	1.16	Hydrogen sulfide	1.54
Air	1.29	Methane	0.72
Ammonia	0.77	Nitric oxide	1.34
Carbon dioxide	1.98	Nitrogen	1.25
Carbon monoxide	1.25	Nitrous oxide	1.98
Chlorine	3.17	Oxygen	1.43
Hydrogen	0.09	Sulfur dioxide	2.93
Hydrogen chloride . . .	1.64		

FOOD CHEMISTRY OUTLINE

A. Compounds Found in the Body and in Foods.

1. Definition of a food.
2. Relation of food to the body.
3. Chief elements found in the body and in foods are carbon, oxygen, hydrogen, nitrogen, sulfur, phosphorus, calcium.
4. The elements are combined to form two classes of compounds in the body and in foods:

I. Inorganic
- 1. Water, H_2O (65 % or more in the body).
- 2. Inorganic salts (mineral matter, ash, 5 % in body, chiefly calcium phosphate).

II. Organic
- Non-nitrogenous (contain carbon hydrogen and oxygen only).
  - 1. Carbohydrates (less than 1 % in body).
    - *a.* Starch group $(C_6H_{10}O_5)_n$.
      - 1. Starch.
      - 2. Glycogen.
      - 3. Dextrin.
      - 4. Cellulose.
      - 5. Gums.
      - 6. Pectin.
    - *b.* Sugars.
      - 1. Sucrose group $(C_{12}H_{22}O_{11})$.
        - *a.* Sucrose — cane sugar.
        - *b.* Lactose — milk sugar.
        - *c.* Maltose — malt sugar.
      - 2. Glucose group $(C_6H_{12}O_6)$.
        - *a.* Dextrose — grape sugar — glucose.
        - *b.* Levulose — fruit sugar — fructose.
        - *c.* Galactose from milk sugar.
  - 2. Fats (12% in body—this varies).
    - *a.* Animal source.
      - 1. Milk — cream, butter.
      - 2. Fatty tissue — lard, tallow, whale oil.
    - *b.* Plant source.
      - 1. Seeds — sunflower, cotton, flax, castor bean.
      - 2. Nuts — coconut, almond, peanut.
      - 3. Fruit — olive, avocado.

II. Organic (*Continued*)

- Nitrogenous Substances or Proteins (contain carbon, hydrogen, oxygen, and nitrogen).
  1. Albumens.
     a. Egg albumen.
     b. Blood albumen.
     c. Milk albumen.
  2. Casein.
  3. Globulins.
     a. Gluten.
     b. Myosin.
     c. Legumen.
  4. Albuminoids or gelatinoids.
     a. Collagen.
     b. Keratin.

B. Inorganic Compounds.

1. Water:

a. Most abundant inorganic compound in the body. It forms 60 % of the body.

b. Tissues in which it is most abundant:

Blood, eyeballs, tears, digestive juices, muscle tissues, lymph, all the important organs of the body.

c. Tissues in which it is the least abundant:

Hair, teeth, bones, nails, skin, fatty tissues.

d. Use of water to the body:

It carries nourishment to and waste from living tissues of the body. It cleans and flushes the system. It regulates the temperature of the body.

e. Supplied to the body:

By drinking it pure and in all beverages such as milk, in soups, melons, fruits, and vegetables.

f. Foods with much water:

See table in Appendix.

g. Foods with little water:

See table in Appendix.

h. Foods with no water:

See table in Appendix.

2. Inorganic salts (mineral matter or ash, 5% of body by weight):
   a. Tissues in which it is most abundant:
      Bones — $Ca_3(PO_4)_2$, $Mg_3(PO_4)_2$, $CaCO_3$, chiefly.
      Hair, nails, skin — SiO_2, CaF_2, chiefly.
      Muscle tissue — Na_2Cl, Na_2CO_3, Na_3PO_4, and KCl, chiefly.
      Blood and all liquids in the body contain nearly the same salt as muscle tissue.
   b. Tissues with little if any inorganic matter:
      Fatty tissues.
   c. Use of inorganic salts to the body:
      To build tissues, aid digestion, and to stimulate the appetite.
   d. Foods containing much:
      See table in Appendix.
   e. Foods with little or none:
      See table in Appendix.

C. Organic Compounds in the Body and in Foods.

1. Organic compounds in the body and in foods are divided into two groups:
   a. *Non-nitrogenous,* containing carbon, hydrogen, and oxygen only.
   b. *Nitrogenous,* containing carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorus.
2. Non-nitrogenous compounds divided into two groups:
   a. *Carbohydrates:*
      Definition of a carbohydrate — examples.
      Forms less than 1% of the body. Why then so important a part of our diet?
   b. *Fats:*
      Definition of a fat — example.
      Why so useful in our diet?

D. A Study of Some of the Important Carbohydrates of the Starch Group.

1. Starch $(C_6H_{10}O_5)_n$:
   - *a.* Vegetables and plants in which it is most abundant.
   - *b.* How obtained commercially.
   - *c.* Physical properties:
     Starch grains from different sources differ in size and shape (microscope).
   - *d.* Chemical properties:
     Effect of gentle dry heat.
     Effect of intense heat without air.
     Effect of concentrated sulfuric acid.
     Products of combustion.
     Hydrolysis of starch.
   - *e.* Manufacture of glucose from starch.
   - *f.* The iodine test for starch.
   - *g.* Foods containing much starch:
     See table in Appendix.
   - *h.* Foods containing little starch:
     See table in Appendix.
   - *i.* Foods containing no starch:
     See table in Appendix.
   - *j.* Commercial uses of starch.
2. Dextrin $(C_6H_{10}O_5)_n$:
   - *a.* Prepared by heating starch from 210° C. to 280° C.
   - *b.* Physical properties, yellow or white, sweet, sticky, soluble in water.
   - *c.* Insoluble in alcohol.
   - *d.* Intermediate product in the hydrolysis of starch.
   - *e.* Effect on iodine solution (red, purple coloration).
   - *f.* Effect on Fehling's solution.
   - *g.* Use of dextrin.
3. Glycogen:
   - *a.* Found in the liver of animals.
   - *b.* Soluble in cold water.

c. Effect on iodine solution (reddish coloration).
d. Use of glycogen to animal.

4. Cellulose $(C_6H_{10}O_5)_n$:
a. Where found:
In nearly all plants, especially the stems, roots, and leaves.
Commercial source is young tree trunks, cotton, hemp, flax, jute, ramie, coconut fiber.
b. How obtained commercially.
c. Physical properties:
Seed fibers or last fibers. Colorless, odorless, tasteless, insoluble in water.
d. Chemical properties:
Dilute acids no effect.
Dilute bases no effect.
Iodine solution no effect.
Fehling's solution no effect.
Concentrated sulfuric acid forms a clear jelly-like mass called amyloid. Longer action forms dextrin. Still longer dextrose.
Strong sodium hydroxide makes cellulose fibers transparent and larger. (Mercerizes them.)
Soluble in a concentrated solution of zinc chloride.
Soluble in Sweitzer's reagent.
Nitric and sulfuric acid changes it to nitrocellulose or guncotton.
Nitrocellulose dissolved in ether and alcohol gives collodion.
Nitrocellulose dissolved in ether and camphor gives celluloid.
e. Commercial uses of cellulose.
f. Uses as food.
g. Foods containing much cellulose.
h. Foods containing little or no cellulose.

5. Gums:
   - *a.* Where found.
   - *b.* How obtained commercially.
   - *c.* Physical properties:
     Effect of cold water, alcohol, ether.
   - *d.* Chemical properties:
     Effect of iodine.
     Effect of Fehling's solution.
     Hydrolysis of gums.
   - *e.* Use of gums in the preparation of foods.
   - *f.* Commercial uses of gums.
6. Pectin:
   - *a.* Where found.
   - *b.* Soluble in hot water.
   - *c.* Physical properties.
   - *d.* Precipitated by alcohol, acid, or sugar.
   - *e.* Hydrolyzed by long boiling with acid.
   - *f.* Fruits containing much pectin.

E. Important Carbohydrates of the Sugar Group.

1. Sucrose — cane sugar, $C_{12}H_{22}O_{11}$:
   - *a.* Substances containing much — roots like beets and carrots, stems of grasses, corn stalks, sugar cane, sap of some trees, birch and maple.
   - *b.* Commercial source — sugar cane, sugar beets.
   - *c.* Preparation of sugar from cane.
     1. Extraction of juice.
     2. Separation of crystals — centrifugal.
     3. Clarifying.
     4. Evaporation.
   - *d.* Preparation from beets.
     1. Wash and slice beets.
     2. Extraction of juice by diffusion cells (osmosis).
     3. Clarifying.

4. Evaporation.
5. Separation of crystals.

e. Physical properties of sucrose.
Color, odor, taste, form, solubility in hot and cold water.

f. Chemical properties of sucrose.
Gentle heat melts it. This, when cold, forms *barley sugar.*
More intense heat changes it to *caramel.*
Strong heat decomposes it.
$C_{12}H_{22}O_{11} + \text{heat} \longrightarrow 12\ C + 11\ H_2O$
Concentrated sulfuric acid decomposes it.
$C_{12}H_{22}O_{11} + (H_2SO_4) \longrightarrow 12\ C + 11\ H_2O$
Will not reduce Fehling's solution.
Boiled with a dilute acid it hydrolyzes.
$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O\ (\text{dilute acid}) \longrightarrow \underset{\text{dextrose}}{C_6H_{12}O_6} + \underset{\text{levulose}}{C_6H_{12}O_6}$
Not easily fermented until yeast hydrolyzes it and the simple sugars so formed undergo fermentation.
$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$
$\underset{\text{glucose}}{C_6H_{12}O_6} + \text{yeast} \longrightarrow \underset{\text{alcohol}}{2\ C_2H_5OH} + \underset{\text{carbon dioxide}}{2\ CO_2}$

g. Use of sucrose as food.
h. Commercial uses.

2. Lactose — milk sugar, $C_{12}H_{22}O_{11}$.
a. Found in milk of all mammals.
b. Prepared from whey.
c. Physical properties of lactose. Color, odor, not so sweet as cane sugar, not so soluble in cold water as cane sugar or grape sugar, more soluble in hot water.
d. Chemical properties of lactose.
Heat melts it.
Intense heat decomposes it.

Sulfuric acid decomposes it.

It will reduce Fehling's solution with $\frac{1}{10}$ the power of dextrose.

Dilute acids hydrolyze it.

$$\underset{\text{lactose}}{C_{12}H_{22}O_{11}} + H_2O \text{ (dilute acid)} \longrightarrow \underset{\text{dextrose}}{C_6H_{12}O_6} + \underset{\text{galactose}}{C_6H_{12}O_6}$$

It is easily fermented by yeast.

e. Use of lactose. In the preparation of children's foods. In pharmacy in the preparation of pellets and tablets.

3. Maltose — malt sugar, $C_{12}H_{22}O_{11}$.

a. Preparation.

1. Malt diastase on starch.
2. Dilute acids on starch.
3. $\underset{\text{starch}}{C_6H_{10}O_5} + H_2O \text{ (dilute acid)} \longrightarrow \underset{\text{dextrin}}{C_6H_{10}O_5} + \underset{\text{maltose}}{C_{12}H_{22}O_{11}}$

b. Chemical properties.

Heat melts it.

Intense heat decomposes it.

Reduces Fehling's solution with $\frac{1}{3}$ the power of dextrose.

Easily fermented.

Dilute acids hydrolyze it.

$$\underset{\text{maltose}}{C_{12}H_{22}O_{11}} + H_2O \text{ (dilute acid)} \longrightarrow \underset{\text{dextrose}}{C_6H_{12}O_6} + \underset{\text{dextrose}}{C_6H_{12}O_6}$$

4. Dextrose-glucose — grape sugar, $C_6H_{12}O_6$.

a. Dextrose, a white, crystalline solid.

Glucose, a white thick sirup.

Grape sugar, heavy brown-white lumps. Three names for the same sugar. The difference in physical properties is due to methods of purifying it.

b. Substances containing much — grapes, apples, apricots, peaches, all fruits, especially dried fruits.

c. Preparation.

(1) Hydrolysis of sucrose.

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O \text{ (dilute acid)} \longrightarrow \underset{\text{dextrose}}{C_6H_{12}O_6} + \underset{\text{levulose}}{C_6H_{12}O_6}$$

(2) Hydrolysis of lactose.

$$\underset{\text{lactose}}{C_{12}H_{22}O_{11}} + H_2O \text{ (dilute acid)} \longrightarrow \underset{\text{dextrose}}{C_6H_{12}O_6} + \underset{\text{galactose}}{C_6H_{12}O_6}$$

(3) Hydrolysis of maltose.

$$\underset{\text{maltose}}{C_{12}H_{22}O_{11}} + H_2O \text{ (dilute acid)} \longrightarrow \underset{\text{dextrose}}{2\ C_6H_{12}O_6}$$

(4) Hydrolysis of cellulose.

$$\underset{\text{cellulose}}{2\ C_6H_{10}O_5} + H_2O \text{ (acid)} \longrightarrow \underset{\text{dextrin}}{C_6H_{10}O_5} + \underset{\text{dextrose}}{C_6H_{12}O_6}$$

(5) Hydrolysis of starch — this is the commercial method.

$$\underset{\text{starch}}{C_6H_{10}O_5} + H_2O \text{ (dilute acid)} \longrightarrow \underset{\text{dextrose}}{C_6H_{10}O_5} + \underset{\text{maltose}}{C_{12}H_{22}O_{11}}$$

$$\underset{\text{maltose}}{C_{12}H_{22}O_{11}} + H_2O \longrightarrow \underset{\substack{\text{dextrose} \\ \text{or glucose}}}{2\ C_6H_{12}O_6}$$

If conversion is not complete, the product is *glucose* (mixture of dextrin, maltose, and dextrose).

If more complete, the product is *grape sugar* (dextrose and maltose).

If conversion is complete, the product is *dextrose.*

d. Physical properties of dextrose.

White, crystalline, odorless, $\frac{3}{5}$ as sweet as sugar, soluble in cold water, more soluble in hot water.

e. Chemical properties of dextrose.

Moderate heat melts it.

Intense heat decomposes it.

$$C_6H_{12}O_6 \longrightarrow 6\ C + 6\ H_2O$$

Concentrated sulfuric acid decomposes it.

$$C_6H_{12}O_6 \longrightarrow 6\ C + 6\ H_2O$$

Ferments with yeast dextrose.

$$\underset{}{C_6H_{12}O_6} + \text{yeast} \longrightarrow 2\ \underset{\text{alcohol}}{C_2H_5OH} + 2\ \underset{\text{carbon dioxide}}{CO_2}$$

Reduces Fehling's solution.

f. Uses of glucose.

5. Levulose — fruit sugar, $C_6H_{12}O_6$

   a. Found in fruits with dextrose.

   b. Prepared by inversion of cane sugar.

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O\ (\text{dilute acid}) \longrightarrow \underset{\text{dextrose}}{C_6H_{12}O_6} + \underset{\text{levulose}}{C_6H_{12}O_6}$$

   c. Properties similar to those of dextrose.

6. Galactose from milk sugar.

   a. Prepared by hydrolysis of milk sugar.

$$\underset{\text{lactose}}{C_{12}H_{22}O_{11}} + H_2O \longrightarrow \underset{\text{gelactose}}{C_6H_{12}O_6} + \underset{\text{dextrose}}{C_6H_{12}O_6}$$

   b. Properties similar to those of dextrose.

F. Fats and Oils.

1. Chemical composition of fats.

   a. Fats are esters, *i.e.* organic salts.

   b. Base + acid $\longrightarrow$ salt + water.

   c. Alcohol + acid $\longrightarrow$ ester + water.

$$\underset{\text{Ethyl alcohol}}{C_2H_5OH} + \underset{\text{acetic acid}}{CH_3COOH} \longrightarrow \underset{\text{ethylacetate}}{CH_3COOC_2H_5} + H_2O$$

   d. Glycerin + acid $\longrightarrow$ fat + water.

$$\underset{\text{glycerin}}{C_3H_5(OH)_3} + 3\ \underset{\text{stearic acid}}{C_{17}H_{35}COOH} \longrightarrow$$

$$\underset{\text{stearin (a fat)}}{(C_{17}H_{35}COO)_3C_3H_5} + 3\ H_2O$$

$$\underset{\text{glycerin}}{C_3H_5(OH)_3} + 3\ \underset{\text{palmitic acid}}{C_{15}H_{31}COOH} \longrightarrow$$

$$\underset{\text{palmitin (a fat)}}{(C_{15}H_{31}COO)_3C_3H_5} + 3\ H_2O$$

$$\underset{\text{glycerin}}{C_3H_5(OH)_3} + 3\ \underset{\text{oleic acid}}{C_{17}H_{33}COOH} \longrightarrow$$

$$\underset{\text{olein (an oil)}}{(C_{17}H_{33}COO)_3C_3H_5} + 3\ H_2O$$

e. Ordinary fats, such as lard and tallow, are mixtures of the esters palmitin and stearin chiefly, while oils, such as olive oil, cottonseed oil, sperm oil, contain more olein than palmitin and stearin.

2. Occurrence of fats and oils.
   a. Animal origin.
      Milk (butter fat).
      Fatty tissue (lard, tallow, whale oil, sperm oil, and cod liver oil).
      Eggs (yolks).
   b. Plant origin.
      Seeds (sunflower, cotton, flax, castor bean, and cacao beans).
      Nuts (coconut, almond, peanut, pecans).
      Fruits (olive, avocado).
3. Methods of obtaining fats and oils.
   a. Heat alone, called rendering (lard, tallow, and other animal fats and oils).
   b. Pressing without heat (olives, peanuts, cotton seeds, and castor beans), called expressing.
   c. Pressing with heat (cocoa beans, coconuts, almonds).
   d. Extraction by means of ether, chloroform, carbon tetrachloride.
4. Physical properties of fats.
   a. Fats are solids, oils are liquids.
   b. Characteristic odor and taste.
   c. Insoluble in water, soluble in gasoline, ether, and chloroform.
   d. With egg albumen, gum arabic, or other mucilage-like substances, oils and fats form emulsions.
   e. Rubbed on paper, oils form a translucent spot. This is the "grease spot" test for oils and fats.

5. Chemical properties of fats.
   a. Intense heat decomposes fats, forming acrolein.
   b. Oils burn, forming carbon dioxide and water.
   c. When boiled with strong bases, fats are first *hydrolyzed* and then *saponified,* i.e. *soaps* are formed. When esters are hydrolyzed by means of sodium hydroxide, the organic acid and the alcohol are formed. The acid then combines with the sodium hydroxide to form a salt thus:

1. $\underset{\text{ethyl acetate}}{CH_3COOC_2H_5} + H_2O \xrightarrow[\text{(by NaOH)}]{} \underset{\text{acetic acid}}{CH_3COOH} + \underset{\text{ethyl alcohol}}{C_2H_5OH}$

2. $\underset{\text{acetic acid}}{CH_3COOH} + \underset{\text{sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{sodium acetate}}{CH_3COONa} + H_2O$

When fats are hydrolyzed by means of sodium hydroxide, the organic acid and the alcohol glycerin are formed. The acid then combines with the sodium hydroxide to form a *soap,* thus:

1. $\underset{\text{stearin (a fat)}}{(C_{17}H_{35}COO)_3C_3H_5} + 3\ H_2O$ (by NaOH)

   $\longrightarrow 3\ \underset{\text{stearic acid}}{C_{17}H_{35}COOH} + \underset{\text{glycerin}}{C_3H_5(OH)_3}$

2. $\underset{\text{stearic acid}}{C_{17}H_{35}COOH} + \underset{\text{sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{sodium stearate (a soap)}}{C_{17}H_{35}COONa} + H_2O$

6. Uses of fats as food.
   a. Give $2\frac{1}{4}$ times as much heat to the body as the carbohydrates.
7. Commercial use of fats.
   a. For preserving meats and fish, for lubricants, for varnishes, paints, soaps, candles.

G. Nitrogenous Substances or Proteins.

1. Albumens — soluble in cold water, coagulated by heat.
   a. Where found (milk, egg, blood).
   b. Physical properties — solubility.

c. Effect of heat, odor.
d. Decomposed by soda lime gives ammonia.
e. Xanthoproteic test.
f. Millon's test.
g. Use to body.

2. Casein — soluble in cold and hot water.
a. Where found (milk of all mammals).
b. Precipitated by any acid.
c. Coagulated by rennin.
d. Effect of heat — odor.
e. Xanthoproteic test.
f. Millon's test.
g. Decomposition test.

3. Globulins — insoluble in hot or cold water.
Gluten in wheat and other cereals.
a. Physical properties — solubility.
b. Effect of heat — odor.
For other tests see 1 and 2 above.
Myosin in meat.
a. Effect of heat — odor.
For other tests see 1 and 2 above.
Legumen in peas and beans.
For tests see 1 and 2 above.

4. Albuminoids or gelatinoids — soluble in hot water, on long boiling. Form jellies on cooling.
Collagen in cartilage, skins and bones.
a. Will not give Xanthoproteic test.
b. Will not give Millon's test.
c. When heated — odor.
d. Decomposition test.
e. Used to make commercial gelatin.
Keratin in hair, hoofs, nails, very insoluble, contains much sulfur.
a. For chemical properties see collagen above.

b. Contains more sulfur than other proteins.
c. Used to make glue.
d. No food value.

DIGESTION OF FOODS

A. Starch Group.

1. Starch.
   In mouth, cooked starch changed to maltose and dextrose.
   In stomach, no change.
   In small intestine, cooked and uncooked starch completely changed to maltose and dextrose.
2. Cellulose not digested. It is softened in small intestine.

B. Sugar Group.

1. Sucrose, lactose, maltose.
   In mouth, no change.
   In stomach, the acids present partly hydrolyze them to the simple sugars.
   In small intestine, completely hydrolyzed by the ferment invertin.
2. Glucose, levulose, galactose.
   Ready for the blood without being changed.

C. Fats.

In the mouth, no action.
In the stomach no action.
In the small intestine:

1. Some of the fats form emulsions with the proteins present.
2. Steapsin splits fats into fatty acids and glycerin.

$$\underset{\text{stearin}}{C_3H_5(C_{17}H_{35}COO)_3} + 3\,H_2O \longrightarrow \underset{\text{glycerin}}{C_3H_5(OH)_3} + 3\,\underset{\text{stearic acid}}{C_{17}H_{35}COOH}$$

3. Then the fatty acid plus the alkali present forms soaps.

$$\underset{\text{fatty acid}}{C_{17}H_{35}COOH} + NaOH \longrightarrow \underset{\text{soap}}{C_{17}H_{35}COONa} + H_2O$$

4. Fat and soaps form an emulsion.

D. Digestion of Proteins.

1. In mouth, no action.
2. In stomach:
   Dissolved proteins coagulated by rennin and acid.
   All coagulated proteins changed to peptones by ferment pepsin aided by acids.
3. In small intestine:
   All proteins changed to peptones by ferment trypsin.

ACTION OF DIGESTIVE JUICES

Name of Digestive Juice	From	Action in	Alkaline or Acid	Name of Ferment	Action of Ferment
Saliva	Salivary gland	Mouth	Alkaline	Ptyalin	Cooked starch to maltose. Acts slowly on glycogen. No effect on cellulose or uncooked starch.
Gastric juice	Walls of stomach	Stomach	Acid (lactic and hydrochloric acids)	1. Acid alone 2. Acid alone 3. Rennin 4. Pepsin	1. Sucrose group of sugars hydrolyzed to dextrose. 2. Coagulates proteins. 3. Coagulates proteins. 4. Proteins to peptones. Starch not changed in stomach.

Name of Digestive Juice	From	Action in	Alkaline or Acid	Name of Ferment	Action of Ferment
Pancreatic juice	Pancreas	Small intestine	Alkaline	1. Amylopsin 2. Invertin 3. Steapsin 4. Trypsin	1. All starch to maltose. 2. Sucrose, maltose, lactose to simple sugars. 3. Splits fats into fatty acids and glycerin. Fatty acids plus alkalies form soap. Soap plus fat forms an emulsion. Proteids plus fat form an emulsion. 4. Proteins to peptones.

TABLES SHOWING AVERAGE HEIGHT, WEIGHT, SKIN SURFACE, AND FOOD UNITS REQUIRED DAILY WITH VERY LIGHT EXERCISE

Boys

Age	Weight in Pounds	Calories or Food Units
5	41.09	816.2
6	45.17	855.9
7	49.07	912.4
8	53.92	981.1
9	59.23	1043.7
10	65.30	1117.5
11	70.18	1178.2
12	76.92	1254.8
13	84.85	1352.6
14	94.91	1471.3

TABLES SHOWING AVERAGE HEIGHT, WEIGHT, SKIN SURFACE, AND FOOD UNITS REQUIRED DAILY WITH VERY LIGHT EXERCISE (*Continued*)

GIRLS

Age	Weight in Pounds	Calories or Food Units
5	39.66	784.5
6	43.28	831.9
7	47.46	881.7
8	52.04	957.1
9	57.07	1018.5
10	62.35	1081.0
11	68.84	1148.5
12	78.31	1276.8

MEN

Height in Inches	Weight in Pounds	Calories or Food Units			
		Proteids	Fats	Carbohydrates	Total
61	131	197	591	1182	1970
62	133	200	600	1200	2000
63	136	204	612	1224	2040
64	140	210	630	1260	2100
65	143	215	645	1290	2150
66	147	221	663	1326	2210
67	152	228	684	1368	2280
68	157	236	708	1416	2360
69	162	243	729	1458	2430
70	167	251	753	1506	2510
71	173	260	780	1560	2600
72	179	269	807	1614	2690
73	185	278	834	1768	2780
74	192	288	864	1728	2880
75	200	300	900	1800	3000

Women

Height in Inches	Weight in Pounds	Calories or Food Units			
		Proteids	Fats	Carbohydrates	Total
59	119	179	537	1074	1790
60	122	183	549	1098	1830
61	124	186	558	1116	1860
62	127	191	573	1146	1910
63	131	197	591	1182	1970
64	134	201	603	1206	2010
65	139	209	627	1254	2090
66	143	215	645	1290	2150
67	147	221	663	1326	2210
68	151	227	681	1362	2270
69	155	232	696	1392	2320
70	159	239	717	1434	2390

Note. — With active exercise an increase of about 20 per cent total food units may be needed.

TABLE OF 100 FOOD UNITS

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbohydrate
Cooked Meats						
Beef, round, boiled (fat)	Small serving .	36	1.3	40	60	00
Beef, round, boiled (lean)	Large serving .	62	2.2	90	10	00
Beef, round, boiled (med.)	Small serving .	44	1.6	60	40	00
Beef, 5th rib, roasted	Half serving . .	18.5	.65	12	88	00
Beef, 5th rib, roasted	Small serving .	32	1.2	25	75	00
Beef, 5th rib, roasted	Very small serving	25	.88	18	82	00
Beef, ribs, boiled . .	Small serving .	30	1.1	27	73	00

TABLE OF 100 FOOD UNITS (*Continued*)

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbo-hydrate
Cooked Meats (*Continued*)						
Beef, ribs, boiled . .	Very small serving	25	.87	21	79	00
Chicken, canned . .	One thin slice .	27	.96	23	77	00
Lamb chops, boiled, av.	One small chop .	27	.96	24	76	00
Lamb, leg, roasted .	Ord. serving . .	50	1.8	40	60	00
Mutton, leg, boiled .	Large serving .	34	1.2	35	65	00
Pork, ham, boiled (fat)	Small serving .	20.5	.73	14	86	00
Pork, ham, boiled . .	Ord. serving . .	32.5	1.1	28	72	00
Pork, ham, roasted (fat)	Small serving .	27	.96	19	81	00
Pork, ham, roasted (lean)	Small serving .	34	1.2	33	67	00
Turkey, as pur., canned	Small serving .	28	.99	23	77	00
Veal, leg, boiled . .	Large serving .	67.5	2.4	73	27	00
Uncooked Meats, Edible Portion						
Beef, loin, av. (lean)	Ord. serving . .	50	1.8	40	60	00
Beef, loin, av. (fat) .	Small serving .	30	1.1	22	78	00
Beef, loin, porterhouse steak, av.	Small steak . .	36	1.3	32	68	00
Beef, loin, sirloin steak, av.	Small steak . .	40	1.4	31	69	00
Beef, ribs, lean, av. .	Ord. serving . .	52	1.8	42	58	00
Beef, round, lean, av.	Ord. serving . .	63	2.2	54	46	00
Beef, tongue, av. . .	Ord. serving . .	62	2.2	47	53	00
Chicken (broilers), av.	Large serving .	90	3.2	79	21	00
Clams, round in shell, av.	Twelve to 16 . .	210	7.4	56	8	36
Cod, whole	Two servings . .	138	4.9	95	5	00
Goose (young), av. .	Half serving . .	25	.88	16	84	00
Halibut steaks, av. .	Ord. serving . .	81	2.8	61	39	00
Liver (veal), av. . .	Two small servings	79	2.8	61	39	00
Lobster, whole, av. .	Two servings .	117	4.1	78	20	2
Mackerel (Span.), whole, av.	Ord. serving . .	57	2	50	50	00

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbohydrate
Uncooked Meats, Edible Portion (*Continued*)						
Mutton leg, hind, lean, av.	Ord. serving	50	1.8	41	59	00
Oysters, in shell, av.	One dozen	193	6.8	49	22	29
Pork, loin chops, av.	Very small serving	27	.97	18	82	00
Pork, ham, lean, av.	Small serving	36	1.3	29	71	00
Pork, bacon, med. fat, av.	Small serving	15	.53	6	94	00
Salmon (Cal.), av.	Small serving	42	1.5	30	70	00
Shad, whole, av.	Ord. serving	60	2.1	46	54	00
Trout, brook, whole, av.	Two small servings	100	3.6	80	20	00
Turkey, av.	Two small servings	33	1.2	29	71	00
Vegetables						
Artichokes, av., canned		430	15	14	0	86
Asparagus, av., canned		540	19	33	5	62
Asparagus, av., cooked		206	7.19	18	63	19
Beans, baked, canned	Small side dish	75	2.66	21	18	61
Beans, Lima, canned	Large side dish	126	4.44	21	4	75
Beans, string, cooked	Five servings	480	16.66	15	48	37
Beets, edible portion, cooked	Three servings	245	8.7	2	23	75
Cabbage, edible portion		310	11	20	8	72
Carrots, edible portion, fresh		215	7.6	10	8	82
Carrots, cooked	Two servings	164	5.81	10	34	56
Cauliflower, as purchased		312	11	23	15	62
Celery, edible portion		540	19	24	5	71
Corn, sweet, cooked	One side dish	99	3.5	13	10	77
Cucumbers, edible portion		565	20	18	10	72

TABLE OF 100 FOOD UNITS (*Continued*)

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbohydrate
		Vegetables (*Continued*)				
Egg plant, edible portion		350	12	17	10	73
Lettuce, edible portion		505	18	25	14	61
Mushrooms, as purchased		215	7.6	31	8	61
Onions, fresh, edible portion		200	7.1	13	5	82
Onions, cooked	Two large servings	240	8.4	12	40	48
Parsnips, edible portion	1½ servings	152	5.3	10	7	83
Parsnips, cooked		163	5.84	10	34	56
Peas, green, canned	Two servings	178	6.3	25	3	72
Peas, green, cooked	One serving	85	3	23	27	50
Potatoes, baked	One good sized	86	3.05	11	1	88
Potatoes, boiled	One large sized	102	3.62	11	1	88
Potatoes, mashed (creamed)	One serving	89	3.14	10	25	65
Potatoes, steamed	One serving	101	3.57	11	1	88
Potatoes, chips	One half serving	17	.6	4	63	33
Potatoes, sweet, cooked	Half av. potato	49	1.7	6	9	85
Pumpkins, edible portion		380	13	15	4	81
Radishes, as purchased		480	17	18	3	79
Rhubarb, edible portion		430	15	10	27	63
Spinach, cooked	Two ord. servings	174	6.1	15	66	19
Squash, edible portion		210	7.4	12	10	78
Succotash, canned	Ord. serving	100	3.5	15	9	76
Tomatoes, fresh as purchased	Four av.	430	15	15	16	69
Tomatoes, canned		431	15.2	21	7	72
Turnips, edible portion	Two large servings	246	8.7	13	4	83
Vegetable oysters		273	9.62	10	51	39

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbohydrate
Fruits (Dried)						
Apples, as purchased .		34	1.2	3	7	90
Apricots as purchased		35	1.24	7	3	90
Dates, edible portion .	Three large . .	28	.99	2	7	91
Dates, as purchased .		31	1.1	2	7	91
Figs, edible portion .	One large . . .	31	1.1	5	0	95
Prunes, edible portion	Three large . .	32	1.14	3	0	97
Prunes, as purchased .		38	1.35	3	0	97
Raisins, edible portion		28	1	3	9	88
Raisins, as purchased .		31	1.1	3	9	88
Fruits (Fresh or Cooked)						
Apples, as purchased .	Two apples . .	206	7.3	3	7	90
Apples, baked . . .		94	3.3	2	5	93
Apples, sauce . . .	Ord. serving . .	111	3.9	2	5	93
Apricots, edible portion		168	5.92	8	0	92
Apricots, cooked . .	Large serving .	131	4.61	6	0	94
Bananas, edible portion	One large . . .	100	3.5	5	5	90
Blackberries		170	5.9	9	16	75
Cantaloupe	Half ord. serving	243	8.6	6	0	94
Cherries, edible portion		124	4.4	5	10	85
Cranberries, as purchased		210	7.5	3	12	85
Grapes, as purchased, av.		136	4.8	5	15	80
Grape fruit		215	7.57	7	4	89
Grape juice	Small glass . .	120	4.2	0	0	100
Lemons		215	7.57	9	4	77
Lemon juice		246	8.77	0	0	100
Nectarines		147	5.18	4	0	96
Olives, ripe	About seven . .	37	1.31	2	91	7
Oranges, as purchased, av.	One very large .	270	9.4	6	3	91
Oranges, juice . . .	Large glass . .	188	6.62	0	0	100
Peaches, as purchased, av.	Three ordinary .	290	10	7	2	91

TABLE OF 100 FOOD UNITS (*Continued*)

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbohydrate
Fruits (Fresh or Cooked) (*Continued*)						
Peaches, sauce	Ord. serving	136	4.78	4	2	94
Peaches, juice	Ord. glass	136	4.80	0	0	100
Pears	One large pear	173	5.40	4	7	89
Pears, sauce		113	3.98	3	4	93
Pineapples, edible portion, av.		226	8	4	6	90
Raspberries, black		146	5.18	10	14	76
Raspberries, red		178	6.29	8	0	92
Strawberries, av.	Two servings	260	9.1	10	15	75
Watermelon, av.		760	27	6	6	88
Dairy Products						
Butter	Ordinary pat	12.5	.44	.5	99.5	00
Buttermilk	1½ glasses	275	9.7	34	12	54
Cheese, Am., pale	1½ cu. in.	22	.77	25	73	2
Cheese, cottage	Four cu. in	89	3.12	76	8	16
Cheese, full cream	1½ cu. in.	23	.82	25	73	2
Cheese, Neufchâtel	1½ cu. in.	29.5	1.05	22	76	2
Cheese, Swiss	1½ cu. in.	23	.8	25	74	1
Cheese, pineapple	1½ cu. in.	20	.72	25	73	2
Cream	¼ ord. glass	49	1.7	5	86	9
Milk, condensed, sweetened		30	1.06	10	23	67
Milk, condensed, unsweetened		59	2.05	24	50	26
Milk, skimmed	1½ glasses	255	9.4	37	7	56
Milk, whole	Small glass	140	4.9	19	52	29
Cakes, Pastry, Puddings, and Desserts						
Cake, chocolate layer	Half ord. sq. pc.	28	.98	7	22	71
Cake, gingerbread	Half ord. sq. pc.	27	.96	6	23	71
Cake, sponge	Small piece	25	.89	7	25	68
Custard, caramel		71	2.51	19	10	71

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbo-hydrate
Cakes, Pastry, Puddings, and Desserts (*Continued*)						
Custard, milk	Ordinary cup	122	4.29	26	56	18
Custard, tapioca	⅔ ordinary	69.5	2.45	9	12	79
Doughnuts	½ doughnut	23	.8	6	45	49
Lady fingers	Two	27	.95	10	12	78
Macaroons	Four	23	.82	6	33	61
Pie, apple	⅓ piece	38	1.3	5	32	63
Pie, cream	¼ piece	30	1.1	5	32	63
Pie, custard	⅓ piece	55	1.9	9	32	59
Pie, lemon	⅓ piece	38	1.35	6	36	58
Pie, mince	¼ piece	35	1.2	8	38	54
Pie, squash	⅓ piece	55	1.9	10	42	48
Pudding, apple sago		81	3.02	6	3	91
Pudding, brown betty	½ ord. serving	56.6	2	7	12	81
Pudding, cream rice	Very small serving	75	2.65	8	13	79
Pudding, Indian meal	½ ord. serving	56.6	2	12	25	63
Pudding, apple tapioca	Small serving	79	2.8	1	1	98
Tapioca, cooked	Ordinary serving	108	3.85	1	1	98
Sweets and Pickles						
Catsup, tomato, av.		170	6	10	3	87
Candy, plain		26	.9	0	0	100
Candy, chocolate		30	1.1	1	4	95
Honey	Four teaspoons	30	1.05	1	0	99
Marmalade, orange		28.3	1	.5	2.5	97
Molasses, cane		35	1.2	.5	0	99.5
Olives, green, edible portion	Five to seven	32	1.1	1	84	15
Olives, ripe, edible portion	Five to seven	38	1.3	2	91	7
Pickles, mixed		415	14.6	18	15	67
Sugar, granulated	Three heaping teaspoons or 1½ lumps	24	.86	0	0	100
Sugar, maple	Four teaspoons	29	1.03	0	0	100
Sirup, maple	Four teaspoons	35	1.2	0	0	100

TABLE OF 100 FOOD UNITS (*Continued*)

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbohydrate
	Nuts (Edible Portion)					
Almonds, av.	Eight to fifteen	15	.53	13	77	10
Brazil nuts	Three ordinary size	14	.49	10	86	4
Chestnuts, fresh, av.		40	1.4	10	20	70
Filberts, av.	Ten nuts	14	.48	9	84	7
Peanuts, av.	Thirteen double	18	.62	20	63	17
Pecans, polished	About eight	13	.46	6	87	7
Pine nuts (pignolias)	About eight	16	.56	22	74	4
Walnuts, California	About six	14	.48	10	83	7
	Cereals					
Bread, brown, av.	Ord. thick slice	43	1.5	9	7	84
Bread, corn (johnny-cake), av.	Small square	38	1.3	12	16	72
Bread, white, home made	Ord. thick slice	38	1.3	13	6	81
Cookies, sugar	Two	24	.83	7	22	71
Corn flakes, toasted	Ord. cereal dish full	27	.97	11	1	88
Corn meal, granular, av.	2½ level tablespoons	27	.96	10	5	85
Corn meal, unbolted, av.	Three tablespoons	26	.92	9	11	80
Crackers, graham	Two	23	.82	9.5	20.5	70
Crackers, oatmeal	Two	23	.81	11	24	65
Crackers, soda	3½ "Uneedas"	24	.83	9.4	20	70.6
Hominy, cooked	Large serving	120	4.2	11	2	87
Macaroni, av.		27	.96	15	2	83
Macaroni, cooked	Ord. serving	110	3.85	14	15	71
Oatmeal, boiled	1½ servings	159	5.6	18	7	75
Popcorn		24	.86	11	11	78
Popcorn, uncooked		28	.98	9	1	90
Rice, boiled	Ord. cereal dish	87	3.1	10	1	89
Rice, flakes	Ord. cereal dish	27	.94	8	1	91

Name of Food	"Portion" Containing 100 Food Units (Approx.)	Wt. of 100 Calories		Per Cent of		
		Grams	Ounces	Proteid	Fat	Carbohydrate
	Cereals (*Continued*)					
Rolls, Vienna, av. . .	One large . . .	35	1.2	12	7	81
Shredded wheat . .	One biscuit . .	27	.94	13	4.5	82.5
Spaghetti, av. . . .		28	.97	12	1	87
Wafers, vanilla . . .	Four	24	.84	8	13	79
Wheat, flour, entire wheat, av. . . .	Four tablespoons	27	.96	15	5	80
Wheat, flour, graham	$4\frac{1}{2}$ tablespoons	27	.96	15	5	80
Wheat, flour, patent, family, and straight grade spring wheat	Four tablespoons	27	.97	12	3	85
Zweiback	Size thick slice of bread . . .	23	.81	9	21	70
	Miscellaneous					
Eggs, hen's, boiled . .	One large egg .	59	2.1	32	68	00
Eggs, hen's, whites .	Of six eggs . .	181	6.4	100	0	00
Eggs, hen's, yolks . .	Two yolks . .	27	.94	17	83	00
Omelet		94	3.3	34	60	6
Soup, beef, av. . . .		380	13	69	14	17
Soup, bean, av. . . .	Very large plate	150	5.4	20	20	60
Soup, cream of celery	Two plates . .	180	6.3	16	47	37
Consommé		830	29	85	00	15
Clam chowder . . .	Two plates . .	230	8.25	17	18	65
Chocolate, bitter . .	Half a square .	16	.56	8	72	20
Cocoa		20	.69	17	53	30
Ice cream (Phila.) . .	Half serving . .	45	1.6	5	57	38
Ice cream (N. Y.) . .	Half serving . .	48	1.7	7	47	46

SPECIAL SOLUTIONS

1. Cleaning Solution:

Dissolve 25 grams of commercial sodium dichromate in 150 cc. of water, then add 100 cc. of concentrated commercial sulfuric acid. The solution can be used repeatedly.

2. Fehling's Solution:

No. 1. Dissolve 34.64 grams of copper sulfate in 500 cc. of distilled water.

No. 2. Dissolve 173 grams of Rochelle salts and 50 grams of sodium hydroxide in 500 cc. of water. Keep the two solutions in separate bottles. Mix equal parts just before using. The mixture must be alkaline. (For glucose test.)

3. Haine's Solution:

Dissolve 10 grams of $CuSO_4 \cdot 5\ H_2O$ in 875 cc. of water and add 45 grams of KOH sticks. Add 100 cc. of glycerin. This is a single solution reagent and will keep for a year. (Test for glucose.)

4. Halphen's Reagent:

Dissolve 1 gram of sulfur in 100 cc. of carbon disulfide and then add 100 cc. of amyl alcohol. (Test for cottonseed oil.)

5. Iodine (Tincture):

Dissolve 7 grams of iodine and 5 grams of potassium iodide in 100 cc. of 95 % alcohol.

6. Iodine (Starch Test):

5 grams iodine and 10 grams potassium iodide in 250 cc. of water (starch test).

7. Ink Eradicator:

No. 1. Tartaric acid, 20 grams dissolved in 100 grams of water.

No. 2. Boil 5 grams of chlorinated lime in 100 cc. of water until pink color appears. Filter and add enough water to make up to 100 cc. Apply No. 1, absorb excess with blotter, and then apply No. 2. Sponge with ammonia, if used on clothing. Do not use on wool or silk. The following solutions may be used: No. 1. 8 grams of citric acid, 50 cc. of water, and 12 cc. of a saturated solution of borax. No. 2. Boil 18 grams of chlorinated

lime in 60 cc. of water; filter and add 12 cc. of a saturated sol. of borax. Use as in the first case. Not for wool or silk.

8. Javelle Water:

Dissolve 120 grams of sodium carbonate in 250 cc. of water.

Stir 30 grams of chlorinated lime into 250 cc. of hot water.

Mix the two solutions and decant the clear liquid for use as Javelle water.

9. Litmus Solution Indicator:

Powdered litmus should first be heated in alcohol to the boiling point. Filter the undissolved solid from the liquid and allow it to remain for several hours in cold water to remove alkaline impurities. Finally boil the solid residue with about 5 times its weight of water to make the solution for use. Preserve the solution by adding a little chloroform.

10. Logwood Solution:

Boil logwood chips in water till the solution is dark in color. Filter. It must be freshly prepared.

11. Low's Reagent:

Mix 4 volumes of glacial acetic acid with 1 volume of concentrated sulfuric acid.

12. Loewe's Reagent:

Dissolve 35 grams of copper sulfate in 250 cc. of water, and add 12 cc. of glycerin. Add enough sodium hydroxide to dissolve the precipitate that is formed when the hydroxide is first added.

13. Millon's Reagent:

Dissolve mercury in twice its weight of concentrated nitric acid. Dilute with an equal volume of cold water. Decant the clear liquid.

14. Methyl Orange Indicator:

Mix 0.4 gram of methyl orange powder with 30 cc. of 95% ethyl alcohol and 170 cc. of water.

15. Nessler's Solution:

To 50 grams of potassium iodide in distilled water add saturated solution of mercuric chloride to red precipitation. Add 350 cc. of a 50 per cent potassium hydroxide solution. Make up to one liter and allow to settle.

16. Nickel Hydroxide Solution:

Dissolve 5 grams of nickel sulfate in 100 cc. of water and add a solution of NaOH until all the nickel is precipitated as hydroxide. Wash it well and dissolve it in 25 cc. of concentrated NH_4OH and 25 cc. of water. This solution dissolves silk at once, and reduces the weight of vegetable fibers only $\frac{1}{2}$% and of wool only $\frac{1}{3}$%.

17. Phenolphthalein Indicator:

Dissolve 0.4 gram of phenolphthalein in 120 cc. of 95 % ethyl alcohol and add 80 cc. of distilled water.

18. Potassium Hydroxide in Alcohol:

10 grams stick KOH dissolved in 100 grams of alcohol.

19. Potassium Permanganate, Alkaline:

KOH, 200 grams; $KMnO_4$, 8 grams; distilled water, 1250 cc. Boil down to 1 liter.

20. Standard Soap Solution:

10 grams of white castile soap dissolved in 1 liter of dilute alcohol (one third water). Filter if not clear.

21. Sulphanilic Acid:

1 gram of solid in 100 cc. of hot distilled water.

22. Sweitzer's Solution:

Slowly add $CuSO_4$ solution to NaOH solution to precipitation. Filter. Dissolve the residue in NH_4OH. Freshly prepared, it should dissolve cotton immediately.

23. Wood Stain, Acid Proof:

I. Dissolve 125 grams each of $CuSO_4$ and $KClO_3$ in the same liter of water.

II. 150 grams of anilin oil mixed with 180 grams concentrated HCl and a liter of water.

Apply 2 coats of the boiling hot solution I with a brush. Allow each coat to dry. Apply 2 coats of solution II in the same manner. When the wood is dry, wash with hot soapsuds. Finish with raw linseed oil or hot liquid paraffin, and refinish with paraffin when the tables become dingy.

24. Cobalt Chloride Test Paper:

Dissolve 20 grams of $CoCl_2 \cdot 6\,H_2O$ in about 200 cc. of water. Wet filter paper with the solution and dry it. Cut into strips. Dry it over a flame before using it. Be careful in drying not to scorch the paper.

25. Acid Mercuric Nitrate:

Dissolve metallic mercury in twice its weight of concentrated HNO_3 (sp. gr. 1.42) and dilute with twenty-five times its volume of water.